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Lexical Representation and Processing in Cross-Script  
Urdu-English Bilinguals: The Case of Frequency-Balanced and Frequency-Unbalanced  
Cognates and Noncognates

by

Quratulain H. Khan

A Dissertation Submitted to the Faculty of Graduate Studies  
Through the Department of Psychology  
in Partial Fullfillment of the Requirements for  
the Degree of Doctor of Philosophy at the  
University of Windsor

Windsor, Ontario, Canada

2012

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Lexical Representation and Processing in Cross-Script  
Urdu-English Bilinguals: The Case of Frequency-Balanced and Frequency-Unbalanced

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### **Declaration of Originality**

I hereby certify that I am the sole author of this thesis and that no part of this thesis has been published or submitted for publication.

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## **Abstract**

The overall goal of this study was to examine the nature of lexical access and representation of frequency-balanced and frequency-unbalanced cognate and noncognate words in a previously unexamined cross-script language pair. More specifically, Experiment 1 was designed to determine if the cognate advantage obtained for same-script languages in the simple lexical decision task will also be obtained for the Urdu-English language pair. Both facilitation and inhibition effects were obtained for cognate words when participants were tested in English. This indicated nonselective lexical access and interconnectivity of the bilingual mental lexicon. However, when participants were tested in Urdu, a statistically significant cognate effect was not obtained. Experiment 2 was designed to examine whether the discrepancy in findings across cross-script studies in terms of the magnitude of the cognate and noncognate priming effect in a masked priming task can be attributed to frequency differences in the word stimuli as proposed previously. No significant priming effect was obtained for cognates or noncognates in any of the frequency-balanced conditions unlike the results from previous studies. However, a significant cognate and noncognate priming effect was found for some of the frequency-unbalanced conditions and again both facilitation and inhibition effects were suggested. The current version of the BIA+ model does not incorporate lateral inhibition effects at the phonological level for cross-script cognates. The findings from this study are explained within the BIA+ framework by allowing for lateral inhibition at the phonological level. In addition, the role of individual differences in language proficiency and processing strategy is also considered.

## **Dedication**

For Mumma and Daddy,  
Who gave me the gift of multilingualism

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## CHAPTER 1

### Introduction

The bilingual mental lexicon has been a subject of study over the last few decades and researchers have been concerned with two main issues (Sanchez-Casas & Garcia-Albea, 2005). Firstly, there is debate concerning whether the representations of the two languages of the bilingual are stored in two separate lexicons or share a common store. Secondly, there is a question about whether lexical access is selective or nonselective, that is, whether only the target language is activated or both the languages are simultaneously activated regardless of the linguistic circumstances (Sanchez-Casas & Garcia-Albea, 2005). These questions are closely linked because the nature of lexical access is determined by the manner in which the two languages are organized (De Groot, Delmaar, & Lupker, 2000).

This dissertation will focus on the representation and processing of cognate words in bilinguals. According to Kroll and De Groot (1997, p. 173), “cognates are generally taken to be words that share aspects of both form and meaning across languages”. While Spanish-English and Dutch-English cognates share a common root due to etymological similarities, many Hebrew cognates are simply borrowed from English and therefore, Gollan, Forster, and Frost (1997) used the term “loan words” to describe Hebrew-English cognates more accurately. Similarly, in Urdu, many modern words are simply borrowed from English and overlap in phonological form and meaning but not in orthographic form. For example, the Urdu word for *college* (**kol**-ij) is کالج (**kä**-lij). Nevertheless, these “loan words” are completely integrated into Hebrew and Urdu and are used across formal and informal settings. For the purposes of the current study, the term “cognate” is

used for those words that share orthographic or phonological form and meaning across languages. The etymology of these words has not been considered. Noncognate translations are defined as words that are similar in meaning but do not overlap in orthographic or phonological form.

A number of studies have examined the way in which cognate words are represented and processed in the bilingual mental lexicon. Various experimental paradigms have shown that cognate words produce behavior that differs from noncognate translations. The *cognate advantage* is seen in word production studies such as picture naming (e.g., Costa, Caramazza, & Sebastian-Galles, 2000; Hoshino & Kroll, 2008) and word translation (e.g., De Groot, 1992b; Sanchez-Casas, Davis, & Garcia-Albea, 1992). Word recognition studies using the lexical decision task have also shown a processing advantage for cognates over noncognates (e.g., Caramazza & Brones, 1979; Cristoffanini, Kirsner, & Milech, 1986; Dijkstra, Van Jaarsveld, & Ten Brinke, 1998; Dijkstra, Grainger, & van Heuven, 1999; Van Hell & Dijkstra, 2002; Lemhofer & Dijkstra, 2004; Lemhofer, Dijkstra, & Michel, 2004), and researchers normally report stronger priming for cognates compared to noncognate translation pairs (Davis, Sanchez-Casas, & Garcia-Albea, 1991, as in Sanchez-Casas & Garcia-Albea, 2005; Gollan, Forster, & Frost, 1997; Voga & Grainger, 2007).

Prior to reviewing the studies that have explored the nature of bilingual lexical representation and access, monolingual models of visual word recognition will be discussed briefly in order to provide a framework within which the bilingual models can be understood. The review of the cognate facilitation effect will be organized in terms of studies tapping into the manner in which the two languages of the bilingual are

represented, and studies investigating the manner in which they are processed. Such a conceptual division has been used by French and Jacquet (2004) to understand data from various studies.

### **Monolingual Models of Visual Word Recognition**

Because language is abstract and not readily revealed through a physical examination of the brain, its representation in the lexicon is understood to be in the form of an abstract pattern consisting of information about visual and auditory characteristics of words and their meanings (Santiago-Rivera & Altarriba, 2002). The idea of the mental lexicon was first introduced by Anne Treisman in 1961, who proposed that this mental “dictionary” contains individual lexical entries or “dictionary units” representing individual words (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001). Each lexical entry contains orthographic, phonological, or semantic information about the word (Coltheart, Davelaar, Jonasson, & Besner, 1977). Orthography refers to information about the visual word form, phonology is information about the auditory word form, while semantic information refers to the meaning. The study of visual word recognition in monolinguals has focused on understanding how word processing is affected by these properties of words and on the question of lexical access (Iyer, 2007). Lexical access is the process by which the appropriate word representation is activated in a given context (French & Jacquet, 2004).

Lexical representation and access have been variously described in a number of models of word recognition over the years. The serial search model proposed by Forster (1976) assumes that word forms are arranged in a frequency-ordered manner in the lexicon such that higher frequency words (i.e., those that are frequently encountered) are

accessed more rapidly than low frequency words. In this model, upon the presentation of a word, that word is compared to the word forms in the lexicon one at a time. The master lexicon has peripheral files attached to it and within each file words are arranged in terms of their orthographic, phonological, semantic, and syntactic properties. An entry for a given word has to be found in an appropriate access file before the master lexicon can be accessed. The search for the appropriate word is ordered by frequency from high-frequency words to low-frequency words.

Morton (1969) proposed a parallel-access model in which each word in the lexicon is represented by a *logogen*. This is a recognition unit that contains orthographic, phonological, semantic, and syntactic information about a word and has a level of activation based on the degree of overlap with the incoming stimulus (Morton). When a particular stimulus is presented, the activation level of the corresponding logogen rises and once the recognition threshold is reached, the cognitive system gains access to the information contained in the logogen (as in Iyer, 2007). Logogens containing information about high-frequency words have permanently higher resting levels of activation compared to low-frequency words due to their repeated presentations to the logogen and this assumption explains the effect of word frequency (Morton).

Other models make use of both the serial search and the parallel-access mechanisms. These include the verification model (Becker, 1976) and the activation-verification model (Paap, Newsome, McDonald, & Schvaneveldt, 1982). These models propose a two-stage process for word recognition. The first stage is the activation stage and is characterized by the parallel activation of a set of candidates, which share features with the presented stimulus. The second stage is the verification stage and entails an item

by item examination of the activated candidates until a match is identified (Monsell, Doyle, & Haggard, 1989). In this stage, lexical units are verified in a frequency-ordered manner leading to faster identification of high-frequency words compared to low-frequency words (Becker; Paap et al.; Monsell et al.).

The Interactive Activation (IA) model of McClelland and Rumelhart (1981) is a connectionist model, which proposes three hierarchically arranged levels of representation including a visual feature level, a letter level, and a word level. Excitatory and inhibitory connections exist between the nodes within each of these levels as well as between the nodes of adjacent levels. When a word is presented, it activates particular features at the visual feature level, which in turn activates the letters containing these features. Activation is carried forward to words that contain the activated letters. In addition to this bottom-up activation, top-down activation also occurs such that word-level nodes send feedback down to letter-level nodes. Nodes that are dissimilar to the input are inhibited at all the levels. Due to this parallel process of activation and inhibition a single word eventually becomes highly activated. Whereas the activation level of a word node depends on the presentation of a stimulus, its resting level is determined by the level of activation over time. Word frequency effects in this model are explained by assuming that the nodes for high-frequency words have higher resting levels of activation than low-frequency words.

The model of Seidenberg and McClelland (1989) is also a connectionist model. However, unlike the models described previously, where each word in the lexicon has an individual entry or “localist” representation (Iyer, 2007), this is a distributed memory model. This means that the orthographic, phonological, and semantic codes within the



model have a distributed representation such that the pattern of activation is distributed over numerous representational units. A particular entity is encoded as a specific pattern of activity over numerous units and information about word frequency is reflected in differences in the strength or weight of the connections between the units such that high-frequency words are represented by stronger connections compared to low-frequency words (Seidenberg & McClelland, 1989).

The Dual Route Cascaded (DRC) model (Coltheart et al., 2001) comprises of three routes: the lexical semantic route, the lexical nonsemantic route, and the grapheme-phoneme correspondence (GPC) route. A number of interacting layers containing sets of units are present within each of the routes. A unit is the smallest element in this model and may be, for example, a visual feature, a letter, a phoneme, or a word depending on the layer of which it is a part. This model is similar to the IA model in that there are inhibitory and excitatory connections across the units within a layer as well as between layers. The lexical nonsemantic route operates in the following manner: when a stimulus is presented letter features activate the letter units of the word in parallel, which in turn activate the representation of the word in the orthographic lexicon. Subsequently, the representation of the word in the phonological lexicon is activated, which activates the word's phonemes in parallel. The GPC route uses grapheme-phoneme correspondence rules to convert letter strings into strings of phonemes. On the presentation of a word, letter features and letters are activated in a manner similar to the lexical nonsemantic route. The activation in the letters is passed on as activation in specific phoneme units based on GPC rules.

These models make various assumptions about the processes that come into play in monolingual word recognition. All have, as a minimum requirement, the ability to accommodate the ubiquitous word frequency effect among other less robust effects. Bilingual models of lexical access and representation are impacted by the assumptions of the particular monolingual model adopted by bilingual researchers and in turn impact the questions that are asked about bilingual language access and representation and the methods used to answer them. As in monolingual research, word frequency is an important manipulation in bilingual studies that can reveal a great deal about linguistic processing.

### **The Nature of Bilingual Lexical Representation**

The main question regarding bilingual lexical representation is whether there is a single memory store for both languages or two separate stores (for reviews see: Francis, 1999; Heredia, 1997; Kroll & Tokowicz, 2005). The earliest account of bilingual lexical representation was proposed by Weinreich (1953, as in Kroll & Tokowicz) according to which bilinguals can have a single memory store for both languages (*compound bilingualism*) or two separate stores (*coordinate bilingualism*). Later, these views came to be known as the *single store hypothesis* and the *separate store hypothesis*, respectively (Kollers, 1963, 1966). Subsequent research provided support for both models and the inconclusive findings were attributed to the failure of researchers to differentiate between the conceptual and the lexical levels of representation (Eck, 1998). Potter, So, Von Eckardt, and Feldman (1984) proposed a hierarchical framework consisting of separate lexical and conceptual representations (for reviews see: Heredia, 1997; French & Jacquet, 2004).

Subsequent research focused on “how and to what extent the words from the bilingual’s two languages are interconnected at both the lexical and conceptual levels” (Sanchez-Casas & Garcia-Albea, 2005, p. 226). Potter et al. (1984) proposed two hierarchical models: the word association model and the concept mediation model. The word association model proposes a direct link between L1 (dominant language) and L2 (nondominant language) words, a direct link between the L1 word and its corresponding concept, but no direct link between the L2 word and its corresponding concept. Thus, L2 words are connected to the conceptual level via their L1 translations. The concept mediation model proposes that no direct links exist between L1 and L2 words, but rather L1 and L2 words are linked in an indirect manner via the shared conceptual system.

Two types of variables are believed to determine the nature and extent of the lexical and conceptual connections (Sanchez-Casas & Garcia-Albea, 2005). These are “variables related to the language user such as level of proficiency, experience, and learning environment of the second language; and word type variables, such as ‘cognate status,’ concreteness, and word frequency” (Sanchez-Casas & Garcia-Albea, p. 227).

The Revised Hierarchical Model (Kroll & Stewart, 1994) takes into account variables related to the language user, more specifically, the changes in bilingual representation and processing that are a result of increasing second language proficiency. According to this model, words in the two languages of a bilingual may be connected directly at the lexical level, or indirectly through the conceptual representation. The strength of these links varies such that at the lexical level, the connection from the L2 word to its L1 translation is believed to be stronger than the connection from the L1 word to its L2 translation. Further, the connection between the L1 word and its concept is

believed to be stronger than the connection between the L2 word and its concept. This is a localist model such that a single node represents the shared concept (Grainger & Frenck-Mestre, 1998). Other models take into account word type variables, such as cognate status, that may determine the nature of lexical and conceptual representation for the two languages of a bilingual.

De Groot and Nas (1991) presented a localist model of cognate and noncognate representation in the bilingual lexicon based on translation and associative (semantic) priming studies. They tested Dutch-English bilinguals on a lexical decision task using a masked priming paradigm. Enhanced translation priming was observed for cognates (e.g., prime: *cat*, target: *kat*) compared to noncognates (e.g., prime: *bible*, target: *vos*, meaning *fox*). However, when the prime-target pair comprised of semantic associates, a priming effect was only obtained for cognate translations (e.g., prime: *author*, target: *boek*, meaning *book*) and not for noncognate translations (e.g., prime: *boy*, target: *meisje*, meaning *girl*). Based on these results, they inferred that the representations of both cognate and noncognate translations are connected at the lexical level. However, only “cognate translations share a representation at the conceptual level and these shared representations are connected to those of associatively (semantically) related words at the same level” (De Groot & Nas, p. 117). Noncognate translation pairs have separate conceptual representations, and these representations “only have connections to those of associatively (semantically) related words of the same language” (De Groot & Nas, p. 117). In this model, a single node at the lexical level represents a whole word and a single node at the conceptual level represents the meaning of the word (De Groot, 1992a). This model is in contrast to the one proposed by Sanchez-Casas, Davis, and Garcia-Albea

(1992), which was based on masked priming studies with Spanish-English bilinguals using the lexical decision, semantic categorization, and cued translation tasks. This model proposes the presence of “shared representations at the lexical level” for cognate words, while noncognate words are represented separately.

De Groot (1992a, 1992b, 1993) later rejected her earlier view of shared conceptual representations for cognates unlike noncognates and presented a distributed model of bilingual memory, based on findings from word translation, translation recognition, word association, and semantic and translation priming studies. In a distributed model the semantic representation is distributed across various units of meaning (Grainger & Frenck-Mestre, 1998). This model could also explain the results from the previous study by De Groot and Nas (1991). According to this model, the concept associated with each word, for example, *vader* (father) is spread over a number of nodes each one of which represents a particular meaning element of *vader* such as “is human,” “is male,” etc. Thus, instead of a single connection between the lexical node for *vader* and its conceptual node, connections exist between the lexical node for *vader* and each of the conceptual representations. When the word *vader* is presented, each of the conceptual elements receives excitatory activation through its lexical node connection (De Groot, 1992a). This model can accommodate the fact that the overlap of meaning for translation pairs is often not complete. Certain types of words have greater conceptual overlap with their translations than others. For example, concrete words and cognate words may share more conceptual overlap than abstract words and noncognate words, respectively. De Groot (1992a) proposes that the greater the overlap in conceptual representation, the higher the spread of activation from the lexical node to that of its

translation. This will result in faster response times and lower errors on tasks for concrete words and cognate words.

De Groot (1992a) points out that greater conceptual overlap for cognate words compared to noncognate words could be due to a number of reasons. One of these is the differential origin of these two types of words. While cognate translations are derived from the same root this is not the case for noncognate translations. Thus, while cognate words end up sharing a great degree of conceptual overlap if the meaning of the original root word was preserved, this is not the case for noncognates. Also, it is possible that when learning a second language, the form similarity between a cognate and its translation may lead the learner to assume similarity of meaning and consequently to link the new word to the conceptual representation of its known translation. Further, the environment in which the second language is learned influences the degree of conceptual overlap for translation pairs. When a second language is learned in the same environment as the first language and the two languages are used interchangeably, it is likely to lead to overlap in the conceptual representation of the two languages. When the two languages are learned in different environments, the memory structure comprises of separate representations for translation pairs (Ervin & Osgood, 1954, as cited in De Groot, 1992a).

The distributed model can explain the existence of a translation priming effect for cognates and noncognates (greater priming for cognates) and the existence of an associative (semantic) priming effect for cognates but not for noncognates that was obtained by De Groot and Nas (1991). At least partially overlapping conceptual representations for cognates and noncognate translation pairs would allow translation

priming for these. As cognates are likely to have greater conceptual overlap, the priming effect would be greater for cognate pairs. If at the same time, “none of the nodes representing the various meaning elements in these conceptual representations is linked to the lexical node of the relevant target word in an interlingual semantic-priming condition” (De Groot, 1992a, p. 402), a semantic priming effect would not be seen for noncognates.

Kroll and De Groot (1997) extended the distributed model (De Groot, 1992a, 1992b, 1993) by adding shared lexical-level units that resemble the conceptual features of the earlier model in the manner in which they are distributed. While earlier work in the field led to the assumption of separate storage for word forms across languages, this addition to the model was made based on the findings of Grainger (1993) and Grainger and Dijkstra (1992). These authors proposed that similarity in lexical form across languages may lead to parallel activation of shared lexical units (Kroll & De Groot, 1997). The Distributed Lexical/Conceptual Feature Model assumes shared lexical- and conceptual-feature levels as well as a language-specific lemma level. The shared lexical-feature level can have multiple layers in order to represent various aspects of lexical form (orthographic and phonological). The lemma level allows for functional autonomy when the bilingual is in the monolingual mode while at the same time allowing for the two languages to exert influence on each other and “to share access to a common pool of lexical and conceptual features” (Kroll & De Groot, p. 191).

Sanchez-Casas and Garcia-Albea (2005) proposed an addition to Kroll and De Groot’s (1997) model based on findings from studies by Christoffanini, Kirsner, and Milech (1986), Garcia-Albea, Sanchez-Casas, and Igoa (1998), and Sanchez-Casas,

Garcia-Albea, and Igoa (2000). These studies provided evidence that “cognate priming effects are the same as priming effects observed with morphologically related words” (Sanchez-Casas & Garcia-Albea, p. 237; Garcia-Albea et al.). The authors proposed that “cognate relations can be considered a special kind of morphological relation” (Sanchez-Casas & Garcia-Albea, p. 237) and incorporated a morphological level of representation within this model at which the common root (e.g., *port-*) of the cognate translations (e.g., *porta-puerta*, meaning “door”) is represented jointly. Thus, when a prime is presented it activates features at the form level. This activation is carried forward to the morphological level. This preexisting activation at the level of form and morphology will result in a quicker recognition response when the target word is presented (Sanchez-Casas & Garcia-Albea). Voga and Grainger (2007), however, found evidence against the proposal that the cognate priming effect is a morphological priming effect. They studied Greek-French bilinguals on a masked priming study looking at the strength of cross-script priming effects for cognates and morphological primes when phonological primes were used as a baseline condition. They found robust priming for cross-script cognates at both 50 ms and 66 ms prime durations but a priming effect for morphologically related words only at the longer prime duration. They rejected the morphological account of cognate priming based on their finding that morphological priming does not show the same pattern as cognate priming.

The contribution of overlapping form and meaning to the cognate facilitation effect has also been investigated. Davis, Sanchez-Casas, and Garcia-Albea (1991, as in Sanchez-Casas & Garcia-Albea, 2005) tested highly proficient Spanish-English bilinguals on a masked priming lexical decision task in both language directions (L1-L2



and L2-L1). They studied three types of prime-target relationships. The first condition was a within language condition (e.g., *clear-clear*, *tail-tail*). The second condition was a translation condition with both cognates (e.g., *claro-clear*) and noncognates (e.g., *cola-tail*). In this condition the degree of form overlap in the cognate translations pairs was varied (e.g., *rich-rico*, *tower-torre*). The third condition was a form control condition with nonword primes (e.g., *clarn-clear*, *tair-tail*). A strong cognate priming effect was found, the degree of which was similar to the effect observed for within language prime-target pairs. Further, the orthographic similarity of the cognate translation pairs did not influence the degree of the priming effect suggesting that “the degree of form similarity does not affect the magnitude of the facilitatory effects obtained for cognates” (Sanchez-Casas & Garcia-Albea, p. 230), hence leading the authors to propose that cognate translations are jointly represented in memory.

Garcia-Albea, Sanchez-Casas, and Valero (1996, as cited in Sanchez-Casas & Garcia-Albea, 2005) tested highly proficient Catalan-Spanish bilinguals in both language directions to investigate the contribution of form and meaning to the cross language priming effect. They studied cross-language cognates (e.g., *cotxe-coche*), noncognates (e.g., *gàbia-jaula*), and false friends, which are words with similar form that differ in meaning (e.g., *curta-curva*) in order to determine if meaning (noncognates), form (false friends), or both (cognates) contribute to the priming effect. The size of the cognate effect was the same as the size of the within language priming effect. Noncognates and false friends did not show a priming effect. These results were obtained when priming was carried out in both language directions. Garcia-Albea et al. (1996, as in Sanchez-

Casas & Garcia-Albea) thus concluded that neither form nor meaning alone can lead to facilitation.

The findings from these two studies have led Sanchez-Casas and Garcia-Albea (2005) to conclude that the relationship between cognate words cannot be explained by mere form or meaning overlap but rather that these words “may be represented jointly in the bilingual lexicon” (Sanchez-Casas & Garcia-Albea, p. 233). However, this does not mean that form and meaning by themselves play no role in the masked priming effect. Sanchez-Casas and Almagro (1999, as in Sanchez-Casas & Garcia-Albea) studied highly proficient Catalan-Spanish bilinguals on a masked priming lexical decision task (LDT) using cognates (*puño-puny*), noncognates (*pato-ànec*), and false friends (*coro-corc*). They used three different prime durations (30 ms, 60 ms, and 250 ms) and in doing so manipulated the SOA and the experimental condition (30 ms and 60 ms = masked; 250 ms = unmasked). They observed facilitation for false friends only at very short SOA (30 ms), facilitation for noncognates only at very long SOA (250 ms), and facilitation for cognates on all three prime durations. Consequently, they proposed that form overlap by itself plays a role only at the earliest stages of the process while meaning similarity on its own influences the process only at the later stages of the recognition process.

### **Translation Priming Studies**

In studying the representation of cognate and noncognate words in the bilingual, the priming paradigm is one of the most frequently used experimental paradigms (Sanchez-Casas et al., 1992; Sanchez-Casas & Garcia-Albea, 2005). In this task, a prime word is presented after the fixation point (e.g., an X in the center of the screen) and before the target word. Priming occurs when the processing of a target stimulus benefits

from the prior presentation of a prime. When the priming effect is observed across different language pairs, it is taken as evidence of shared lexical representations or interconnectivity of the prime and the target word. Both semantic and translation priming studies have been used (for reviews see: Altarriba & Basnight-Brown, 2007; Francis, 1999). However, the focus of this review will be on translation priming studies.

In translation priming, the between-language effect (when the prime and target are translation equivalents) is compared to both the within-language effect (when both the prime and the target are in the same language) and to baseline or control performance (when the prime is an unrelated word, but see Voga & Grainger, 2007 for an example of phonologically related words used as the baseline condition) in order to draw conclusions about the degree to which languages are interconnected at the lexical level (Francis, 1999; Sanchez-Casas et al., 1992).

A number of studies have looked at translation priming using the “classical” version of the task, which involves a long inter-stimulus-interval (several minutes) between the presentation of the prime and the target (e.g., Brown, Sharma, and Kirsner, 1984 ; Christoffanini et al., 1986; Gerard & Scarborough, 1989; Kirsner, Brown, Abrol, Chadha, & Sharma, 1980; Kirsner, Smith, Lockhart, King, & Jain, 1984; Scarborough, Gerard, & Cortese, 1984). These studies found a translation priming effect for cognates (e.g., Christoffanini et al.; Gerard & Scarborough, cited in De Groot, 1992a; but see Bowers, Mimouni, & Arguin, 2000 for an exception when using cross-script prime-target pairs) but not for noncognates (e.g., Gerard & Scarborough; Kirsner et al., 1980; Kirsner et al., 1984; Scarborough et al., cited in De Groot, 1992a). These studies have been criticized as it is believed that this version of the task does not tap into automatic

processes and any cognate effect found may be an episodic effect rather than due to spreading activation in bilingual memory (De Groot, 1992a).

Other studies used a priming paradigm in which the presentation of the target word immediately follows the presentation of the prime (e.g., Altarriba, 1992; Chen & Ng, 1989) and a translation priming effect was obtained in these. While the interval between the onset of the prime and the target was short in these studies, the subjects were nonetheless able to identify the prime. It has been noted that when subjects are able to consciously identify the prime, “this stimulus will be recorded in episodic memory, and then it would not be possible to separate a lexical priming effect from general memory effects” (Sanchez-Casas & Garcia-Albea, 2005, p. 228). The short prime-target interval in this case also makes the relationship between the prime and the target transparent, allowing the subjects to develop a response strategy (Sanchez-Casas & Garcia-Albea.).

Another line of research uses the masked priming paradigm (Forster & Davis, 1984) to study the processing and representation of the languages of the bilingual. It involves the presentation of a forward mask (such as a string of number signs, i.e., #####) for 500 ms. This mask is followed by the presentation of the prime word for about 50 ms followed by the target word. The forward masking effect of the number string and the backward masking effect of the target word ensure that the participant is not aware of the presence of the prime word. It is argued that as the participants are unaware of the presence of the prime they would be unable to adopt a strategic response strategy. Further, as the target is presented immediately after the prime, “responses to the target will be sensitive to the more dynamic processes triggered by the prime” (Kim & Davis, 2003, p. 485). Thus, this experimental paradigm is believed to reduce the

influence of episodic and strategic factors compared to unmasked or non-subliminal priming (Kim & Davis; Sanchez-Casas & Garcia-Albea, 2005; Wang, 2008).

A number of studies have used the masked priming paradigm to investigate the nature of bilingual lexical organization for cognate and noncognate translation pairs. For example, masked translation priming studies that have used same-script prime and target pairs that are either cognates or noncognates, have typically shown that translation primes that are cognates show large priming effects (De Groot & Nas, 1991; Davis et al., 1991, as cited in Sanchez-Casas & Garcia-Albea, 2005; Sanchez-Casas & Almagra, 1999, as in Sanchez-Casas & Garcia-Albea,) while translation primes that are noncognates show no priming (Davis et al., as cited in Sanchez-Casas & Garcia-Albea; Grainger & Frenck-Mestre, 1998; Sanchez-Casas & Almagra, as in Sanchez-Casas & Garcia-Albea). De Groot and Nas, Williams (1994), and Basnight-Brown and Altarriba (2007), however, reported facilitation for noncognates. Grainger and Frenck-Mestre (1998) have proposed that the inconsistency in findings may be explained by the language of the prime-target pairs. They proposed that priming effects are obtained for noncognate translation pairs only when the prime is presented in L1 and the target in L2. This was the way in which De Groot and Nas as well as Williams conducted their studies. Grainger and Frenck-Mestre on the other hand presented the primes in L2 and the target words in L1 and obtained no priming effect for noncognates. Indeed, Basnight-Brown and Altarriba obtained a smaller noncognate priming effect in the L2-L1 direction than in the L1-L2 direction. Further, Sanchez-Casas and Garcia-Albea have proposed that variations in the masking procedure used by De Groot and Nas, as well as Williams, may have led to incomplete masking of the prime and led to priming effect for noncognate translations.

In both these studies, the primes were presented in uppercase letters and the targets in lowercase letters, and the length of the prime and target words also varied (Sanchez-Casas & Garcia-Albea). Sanchez-Casas and Garcia-Albea reanalyzed the data from the study by De Groot and Nas and found that with decreasing availability of the prime, the magnitude of the priming effect for noncognate translation pairs also decreased. Hence, the results from this study are consistent with other reports of an absence of a noncognate priming effect. Moreover, Basnight-Brown and Altarriba presented the prime for 100 ms, which is a longer duration than the 50 ms typically used. It can be argued that the longer prime duration may have allowed strategic factors to play a role and this may be why a priming effect for noncognates was obtained in their study in both the L1-L2 and the L2-L1 direction.

While a noncognate priming effect is not consistently found in same-script bilingual studies (Dutch and English, French and English, and Spanish and English), it is a reliable and robust phenomenon in cross-script bilingual studies. These studies have tested Japanese-English (Finkbeiner, Forster, Nicol, & Nakamura, 2004), Hebrew-English (Gollan et al., 1997), Chinese-English (Jiang, 1999; Jiang & Forster, 2001), Korean-English (Kim & Davis, 2003), and Greek-French (Voga & Grainger, 2007) bilinguals.

Another unique feature that emerges in studies on cognate priming with cross-script languages is the processing asymmetry. When primes are presented in L1 and target words in L2, a cognate priming effect is obtained. This is not the case when primes are in L2 and target words are in L1 (Gollan et al., 1997). Same script studies, on the other hand, have shown enhanced priming for cognates in both priming directions,

that is, from L1 to L2 and from L2 to L1 (e.g., De Groot & Nas, 1991). Further, this asymmetry is also obtained for noncognate priming in cross-script studies. The presence of L1-L2 priming using noncognates has been demonstrated (Gollan et al.; Jiang, 1999). However, this priming effect is absent in the L2-L1 direction (Finkbeiner et al., 2004; Gollan et al.; Jiang; Jiang & Forster, 2001). These differences in findings in same-script and cross-script studies have led some researchers to propose that script differences have a strong impact on bilingual lexical representation and processing (e.g., Gollan et al.; Voga & Grainger, 2007).

In their explanation of the noncognate priming effect obtained in cross-script studies, Gollan et al. (1997) have proposed the “orthographic cue” hypothesis. This explanation assumes two distinct lexicons and the script of the prime provides a powerful cue to the reader and directs them to the appropriate lexicon. Thus, the relevant lexicon is accessed more rapidly and there is a greater probability “that the prime will be accessed quickly enough to influence the processing of the target” (Gollan et al., p. 1134). This explanation assumes not only two distinct lexicons but also a serial search mechanism or a parallel search mechanism whereby the search process is staggered so that the search begins earlier in one lexicon compared to the other. Davis, Kim, and Sanchez-Casas (2003), however, propose that this process is not only confined to the case of cross-script priming but also same-script priming where the prime contains a language-specific orthographic feature (e.g., the Spanish character ñ).

Gollan et al. (1997) and Kim and Davis (2003) also propose a mechanism that does not require the assumption of separate lexicons in order to benefit from the orthographic cue. For the case of same script languages, the prime is assumed to activate

its orthographic neighbours in both languages within the unified lexicon (based on the work of Grainger, 1993) thereby resulting in the activation of many distracting competitors. The activated candidates for the expected target language would be checked first and the noncognate prime word would have a lower chance of being accessed in a timely manner to facilitate target processing (Gollan et al.). For cross-script languages, however, the prime will only activate same-script candidates due to the orthographic cue leading to a greater likelihood of a translation priming effect emerging for noncognates. However, this model requires a serial or staggered search mechanism and does not hold up if simultaneous activation of the two languages is assumed (Gollan et al.).

While the orthographic cue hypothesis can explain the cross-script noncognate priming effect, it is unable to explain the processing asymmetry in cross-script priming whereby priming was not obtained for noncognate prime-target pairs in the L2-L1 direction (Gollan et al., 1997). A number of explanations have been proposed to account for the absence of noncognate priming in the L2-L1 direction (Gollan et al.; Jiang, 1999). These include, first, the “temporal constraint hypothesis,” according to which due to the short prime duration and the masking, bilinguals with poor second language proficiency, may not be able to perceive the prime as a word. Second, the “relative speed of processing account” proposes that while the L2 prime is processed, it is processed more slowly than the L1 target. Thus, when the prime duration is short, the L1 target is accessed before its processing can be affected by the L2 prime. Third, the “general activation level hypothesis” proposes that the stronger L1 of the bilingual is more highly activated than the weaker L2. Thus, in L2-L1 priming, the L2 prime will not be activated



strongly and so will be less available for processing, thereby decreasing the chances of an L2-L1 priming effect.

Jiang (1999) provided evidence against these three processing explanations in a study on Chinese-English bilinguals by modifying the experimental conditions such that more time was made available for prime processing (a 50 ms blank interval was inserted between prime and target), the processing of the L1 target was delayed (the SOA was increased to 250), and the level of activation of L2 was increased (both L1 and L2 targets were presented in a single block). Even after these experimental manipulations, no L2-L1 priming was obtained for noncognate prime-target pairs. Jiang noted that as the processing account of the asymmetry in noncognate priming cannot be supported, “a representation-oriented approach seems to be in a better position to explain the asymmetry” (Jiang, p. 71).

The representation-oriented account proposes that the manner in which bilingual memory is represented explains the asymmetry (Gollan et al., 1997; Jiang, 1999). For example, the revised hierarchical model (Kroll & Stewart, 1994) proposes that stronger links exist between L1 words and their concepts compared to L2 words and their concepts (Gollan et al.; Jiang). Therefore, “while an L1 prime activates all the semantic representations needed to interpret an L2 word, an L2 prime activates only some of the semantic representations needed to interpret the L1 translation” (Gollan et al., p. 1136). It follows that if the locus of the priming effect is at the conceptual level, L1-L2 priming should be stronger than L2-L1 priming (Jiang). However, Gollan et al., point out difficulties with this representation account of the asymmetrical priming effect. They propose that the assumption of this account about the locus of the priming effect being at

the conceptual level is problematic as the semantic priming effect obtained within language in a number of studies (e.g., De Groot & Nas, 1991) is very small and cannot account for the translation priming effects obtained. Although translation equivalents have a greater semantic overlap compared to semantically related items, the additional semantic similarity is unlikely to account for the strong translation priming effect whereas no priming is obtained for semantically related pairs (Gollan et al.). Further, the absence of a noncognate priming effect reported in a number of studies using the masked priming paradigm indicates that mere meaning overlap is not solely responsible for the cognate priming effect (Sanchez-Casas & Garcia-Albea, 2005).

Another representation account is offered by the Sense Model (Finkbeiner et al., 2004). This model is based on studies with Japanese-English bilinguals and proposes that translation priming depends on the proportion of shared features or senses. This model holds that lexical form level representations map onto distributed lexical semantic representations and that “semantic features are bundled into semantic senses within distinct lexical semantic representations” (Finkbeiner et al., p. 15). Masked translation priming, within this model, is attributed to “the overlapping semantic features between prime and target” as well as to “the ratio of primed to unprimed senses”. This model assumes a representational asymmetry between the lexical semantic representations of L1 and L2. It is proposed that the number of senses in a lexical semantic representation depends on the number of usages that word has as well as on the knowledge of the bilingual individual of those usages. As bilinguals are generally more proficient in L1 than in L2, they are assumed to be more familiar with the range of usages of L1 words, and hence, the number of semantic senses associated with L1 words is believed to be

greater than for L2 words. In L1-L2 priming, therefore, the proportion of primed senses will be higher than in L2-L1 priming, leading to translation priming asymmetry in lexical decision.

In same-script studies, a consistent advantage has been reported for cognate words over noncognates both in the L1 to L2 and in the L2 to L1 direction. This cognate advantage has led researchers to propose a shared lexical representation (e.g., De Groot & Nas, 1991; De Groot, 1992a, 1992b, 1993; Kroll & De Groot, 1997; Sanchez-Casas et al., 1992). The absence of a cognate advantage in the L2-L1 direction in cross-script studies has led to the proposal that overlap in orthography, phonology, and semantics is required for a shared lexical representation and that cross-script cognate words do not have a special representation in the lexicon relative to noncognate words (Gollan et al., 1997; Voga & Grainger, 2007). However, if cognate words do not have a special status over noncognates, how can the cognate advantage in the L1-L2 direction be explained?

Gollan et al. (1997) propose that the shared phonological structure of cross-script cognates brings about the enhanced priming effect in the L1-L2 direction. Further, they propose that the cognate effect brought about by phonological facilitation is only present when less proficient bilinguals are tested. When less proficient bilinguals are presented L2 target words, they “rely more heavily on phonological computation of L2 words” (Gollan et al., p. 1137). The cognate facilitation would come about as the phonological overlap of the prime and target “would become relevant”.

On the other hand, Voga and Grainger (2007) propose that the cognate advantage is due to the combined effect of semantic priming and form (phonological) priming. They propose that while noncognate prime-target pairs benefit from semantic priming,

they do not benefit from the additional form (phonological) priming like cognate prime-target pairs do. Thus, while noncognates show a priming effect, this effect is smaller than the priming effect for cognates. Unlike previous masked priming studies, Voga and Grainger used a form-related prime rather than an unrelated prime as their baseline condition. They proposed that the cognate advantage should disappear when a form-related prime is used as a control. Their findings were indeed in line with this prediction and they proposed that it is a combination of interconnectivity at the levels of both form and meaning that leads to the priming effect and not because cognates have a special representational status in the bilingual lexicon.

While Gollan et al. (1997) and Voga and Grainger (2007) both found a cognate and noncognate priming effect, the cognate priming effect was larger than the noncognate priming effect (when compared to an unrelated baseline condition). Kim and Davis (2003), on the other hand, did not find a larger cognate effect compared to noncognates in their study on Korean-English bilinguals. In their study, the size of the cognate and noncognate priming effect was similar and this may be problematic for the conclusions drawn by the previous two studies based on the difference in size of priming effects for cognates and noncognates.

Kim and Davis (2003) attributed the difference in findings between their study and those of Gollan et al. (1997) and Voga and Grainger (2007) to the stimulus frequency differences between the studies. While Gollan et al. and Voga and Grainger used target words with an average frequency of 17.5 per million and 21.5 per million respectively, Kim and Davis used target words with an average frequency of 318 per million. Kim and Davis argue that the frequency difference may have led to different processing strategies.

The high frequency words used in their study may have been discriminated from nonwords faster than the lower frequency target words in Gollan et al.'s study due to their higher orthographic familiarity or rapidly accessed semantic information. In Gollan et al.'s study, the lower frequency words had a lower orthographic familiarity and their semantics may have been accessed more slowly leading to a greater reliance on the phonological code and hence to a larger cognate priming effect (Kim & Davis). Kim and Davis propose that target word frequency plays a role in processing and in determining whether phonological or semantic activation would lead to priming. Indeed, differential affects of high- and low-frequency target words have been reported in the case of monolingual semantic priming (e.g., Hines, 1993).

This review indicates that same-script cognate and noncognate translations are processed in a manner different from cross-script cognate and noncognate translations when a masked priming paradigm is used. This discrepancy in findings from same-script and cross-script bilinguals indicates that the lexical representation of translation words may be different for these two types of bilinguals. Thus, there may be a need for different sets of models of lexical representation for same-script and cross-script bilinguals.

### **The Nature of Bilingual Lexical Access**

Another line of research on the bilingual lexicon has focused more specifically on the question of lexical access. Lexical access is the “process of entering the mental lexicon to retrieve information about words” (Dijkstra, 2005, p. 180). Studies in this area have explored whether both languages of a bilingual are activated in parallel when a word specific to one language is presented in a word recognition task (for reviews see:

Brysbaert, 1998; De Groot et al., 2000; Grainger, 1993; Keatley, 1992). The language selective view holds that words from the two languages of a bilingual are separately accessed and require separate lexical networks for different languages (Dijkstra, 2003). Language selection is believed to be a function of “an input switch” that guides incoming visual information to the appropriate lexical system (Dijkstra). This system is highly selective such that only representations of the target language are activated initially and contact is established with the nontarget lexicon only when the search for the corresponding unit in the target lexicon does not result in a match (Dijkstra). The language non-selective access view, on the other hand, holds that candidates from the two languages are activated in parallel (Dijkstra). Evidence has been extended by some authors in favour of language-specific access (e.g., Gerard & Scarborough, 1989; Scarborough, et al., 1984) while other studies have presented evidence for language non-selective access (De Groot et al., 2000; Dijkstra, Timmermans, & Schriefers, 2000; Nakayama, 2002).

The language selective versus non-selective access debate has been studied using cognates (e.g., Dijkstra, Van Jaarsveld et al., 1998; Lemhofer & Dijkstra, 2004; Van Hell & Dijkstra, 2002), interlingual homographs (e.g. Beauvillian & Grainger, 1987; De Groot et al., 2000; Dijkstra et al., 2000; Dijkstra, Van Jaarsveld et al., 1998; Jared & Szucs, 2002; Lemhofer & Dijkstra, 2004), homophones (e.g., Brysbaert, Van Dyck, & Van de Poel, 1999; Doctor & Klein, 1992; Nas, 1983), and orthographic neighbours (e.g., Grainger & Dijkstra, 1992; Van Heuven, Dijkstra, & Grainger, 1998). While cognate words share form (phonological and/or orthographic) and meaning, interlingual homographs share orthographic form only, and interlingual homophones overlap only in

phonological form. Orthographic neighbours are words across the two languages of the bilingual that share all except one letter with the target word. This review will focus on studies that have looked at cognates and interlingual homographs.

When cognates and interlingual homographs are processed differently than control words on a word recognition task such as lexical decision, it is believed that the processing was influenced by the non-target language and this is cited as evidence for the non-selective access view (Kroll & Tokowicz, 2005). When no processing difference is noted for these words compared to control words, it is believed to reflect the absence of cross-language activity and is interpreted as evidence for language selective access (Kroll & Tokowicz). For example, the language non-selective access view holds that Dutch-English cognate words such as FILM, will be processed faster than noncognate words when presented to Dutch-English bilinguals. The presentation of the cognate word is believed to activate the word in the nontarget language as well and shorter reaction time latencies result due to the combined activation in the two languages of the bilingual. The selective access view, on the other hand, does not predict a processing advantage for cognate words as presentation of a cognate word does not activate its reading in the non-target language (Kroll & Tokowicz).

A number of studies have tested the cross-language effect for cognate words and interlingual homographs using the lexical decision task and found evidence for non-selective access in bilinguals (e.g., Caramazza & Brones, 1979; Dijkstra et al., 1999; Dijkstra, Van Jaarsveld et al., 1998; Lemhofer & Dijkstra, 2004; Van Hell & Dijkstra, 2002) as well as for trilinguals (Lemhofer et al., 2004). Lemhofer et al. tested Dutch-English-German trilinguals on a lexical decision task in German (L3, the weakest

language) and presented evidence in favour of the simultaneous activation of all three languages. They presented “triple” cognates (words that overlapped in form and meaning in all three languages), “double” cognates (words that overlapped in form and meaning in Dutch and German only), and German control words and found that the “triple” cognates showed the fastest response latencies, followed by the “double” cognates and finally by the German control words. The advantage of the “triple” cognates over the “double” cognates was believed to be due to the simultaneous activation of the three languages. The authors proposed that as German monolinguals failed to show the effect when tested on the same set of words, the processing advantage observed with the trilinguals was due to the cognate status of these words and provided support for non-selective access in trilinguals. Other studies have failed to find cross-language effects and have been cited as evidence for language selective access.

For example, Gerard and Scarborough (1989) tested Spanish-English bilinguals on a lexical decision task. They found response latencies to high- and low-frequency cognate words to be similar to those for noncognate controls when testing in English (L2 for most participants). Further, when English monolingual participants were tested they recorded similar response latencies to the same word list. When unbalanced interlingual homographs (i.e., words that have a higher frequency in one language than in the other) were tested it was found that reaction times to low-frequency target words were not affected by the higher frequency of the nontarget reading of the homograph. Similarly, high-frequency target words were unaffected by the lower frequency of the nontarget reading. As the frequency of the nontarget reading of the homograph did not effect processing time, the results were taken as evidence for language selective access.



Dijkstra, Van Jaarsveld, et al. (1998) replicated the study by Gerard and Scarborough (1989) with Dutch-English bilinguals and while no cross-language effect was found for the unbalanced interlingual homographs presented, a cognate facilitation effect was found when participants were tested in L2. To explain the presence of facilitation for cognates and the absence of facilitation for interlingual homographs when compared to unrelated control words, they proposed that cognate words share semantic overlap whereas unrelated control words and interlingual homographs do not. They attributed the facilitation for cognates to the “larger activation of (partially) shared semantic representations” (Dijkstra, Van Jaarsveld, et al, p. 55). They also proposed that the combined feedback from the semantic level for the target and nontarget cognate word brings about increased activation at the orthographic level resulting in shorter response latencies compared to the unrelated control words. As interlingual homographs do not share a common semantic form, no facilitation is observed for these compared to the unrelated control words.

The absence of facilitation for interlingual homographs in this experiment indicated that language selective access took place at the level of word form. However, when the task demands were varied, a different picture emerged. In the second experiment, when exclusively Dutch words were included in the stimulus list and participants were instructed to respond “no” to these and the nonwords, inhibitory effects were obtained for the interlingual homographs. In a third experiment when participants were instructed to respond “yes” to both English and Dutch words, a facilitatory effect was obtained for interlingual homographs. Dijkstra, Van Jaarsveld, et al. (1998) argued that when the stimulus list did not include any exclusively Dutch items and the

participants were instructed to respond solely to English items, the English lexicon of the Dutch-English bilinguals would be more highly activated than the Dutch lexicon resulting in an absence of the interlingual homograph effect. When exclusively Dutch words were included, as in the second experiment, the Dutch lexicon was more highly activated. The Dutch readings of the interlingual homographs were more readily available to the participants resulting in delayed processing of the English readings and hence to an overall inhibition. The inability of the participants to completely suppress the activation of the Dutch reading of the interlingual homographs was interpreted to provide evidence for the language non-selective access hypothesis. Further, they found that the size of the inhibitory effect was dependant on the frequency of the Dutch reading of the homographs. High-frequency Dutch homographs were more highly activated than low-frequency Dutch homographs leading to stronger inhibition effects in the second experiment. The strongest inhibition was obtained for low-frequency English homographs with high-frequency Dutch readings. In the third experiment, when a “yes” response was required for both English and Dutch words, a response could be made based on the reading of the homograph that was available first. As high-frequency Dutch homographs would be more highly activated than low-frequency Dutch homographs, these resulted in the strongest facilitation. Because the relative frequency of the interlingual homographs determined the way in which they were processed, the proposal that interlingual homographs have a shared orthographic representation was rejected because a shared orthographic representation “would be characterized by a common, cumulative frequency and would not be affected by the relative frequencies in the two languages” (Lemhofer & Dijkstra, 2004, p. 535). While Dijkstra, Van Jaarsveld et al.

(1998) attributed the lack of effect in their first experiment and in the study by Gerard and Scarborough (1989) to variation in levels of activation due to stimulus list composition and the task demands, De Groot, et al., (2000) offer an explanation based on the participants' response strategy.

De Groot et al. (2000) tested Dutch-English participants and studied the effect of relative frequency and language dominance on the size of the homograph effect. They carried out a simple lexical decision task where half the participants were instructed to respond "yes" to Dutch words and the other half to English words. In addition to the interlingual homographs, half the participants were presented Dutch control words and the other half were presented English control words. An inhibitory effect was observed in the Dutch target condition but not in the English target condition. This was unexpected as in the Dutch target condition the nontarget language (English) was the nondominant language and should have had a lower activation level. The authors proposed that contrary to the instructions, some participants may have responded "yes" to whichever reading of the homograph that was activated first as there was no penalty to doing so. This processing strategy may have led to facilitation, whereas those following the instructions strictly may have shown inhibition and evidence of non-selective access failed to emerge in the English target condition due to the mixed processing strategy adopted. In the Dutch target condition, they would have followed the instructions resulting in a net inhibition effect, whereas in the English target condition, adhering strictly to the instructions would make the task harder, and they were more likely to adopt a language neutral strategy. They tested this hypothesis in a separate experiment by introducing a penalty for using a language-neutral processing strategy such that

participants were required to respond “no” to words from the nontarget language that were added to the stimulus list. An inhibitory effect for homographs was observed both in the Dutch target and English target conditions, but only when the targets had a low frequency. Further, the relative frequency of the two readings also affected the results such that for low-frequency target words the inhibition was the highest. These results confirmed their hypothesis that performance depends on the strategy adopted by the participants.

When participants respond “yes” to words in the target language only as per the instructions, “the inappropriate reading of the homograph may delay the response. As a consequence, interlexical homographs will be responded to more slowly than matched controls” (De Groot, et al., 2000, p. 401). On the other hand, if participants respond “yes” to either reading of the homograph, a facilitation effect will be observed. However, when the task instructions include making a “no” response to words from the nontarget language, this is not the case. Further, the activation level of the two readings of the homographs influences the size of the effect. For example, when the target reading is highly activated and the nontarget reading only slightly so, the nontarget reading will have only a slight or non-existent effect on reaction time and the data may appear to support the language selective access view. However, when the level of activation of the nontarget reading is higher than that of the target reading, it will have a strong effect on the response latency. The relative frequency of the two readings of the homograph and the relative proficiency of the bilingual are factors believed to influence the relative activation levels of the two readings of homographs (De Groot, et al., 2000). As high frequency words have higher baseline levels of activation than low-frequency words, they

are more available to affect processing. Also, when the nontarget reading is in the dominant language of the participant, it has a higher baseline activation level and will have a stronger influence on the reaction time than if the nontarget reading is in the nondominant language. Based on their findings De Groot, et al. (2000) proposed that bilingual lexical access is non-selective and that the combination of language-neutral and language-specific task performance resulted in the pattern of results indicating language selective access in some experiments (e.g., De Groot, et al., 2000, Exp 2; Dijkstra, Van Jaarsveld, et al., 1998, Exp 1; Scarborough & Gerard, 1989).

In addition to the lexical decision studies presented above, priming studies have also provided evidence for non-selective access. A priming study by Beauvillian and Grainger (1987) investigated interlingual homographs and provided support for the language non-selective access hypothesis. They presented English target words to English-French bilinguals that were preceded by either homographic or nonhomographic prime words at two SOA durations (150 ms and 750 ms). The participants were told that the prime words were in French without any indication of the homographic status of these primes. Nevertheless, the English reading of the homographs primed the English target words (e.g., *coin*, which means “corner” in French, primed *money*). This effect was obtained at the shorter SOA duration but not when the SOA was increased. Beauvillian and Grainger proposed that the nontarget reading of the prime is activated immediately but suppressed or rejected later. Beauvillian and Grainger also examined the effect of relative frequency on language access and found that the frequency of the nontarget language also influenced processing thereby providing evidence for nonselective access.

While a number of studies have examined the processing of frequency-unbalanced interlingual homographs, this is not the case for frequency-unbalanced cognates. Dijkstra, Van Jaarsveld et al. (1998) attempted to manipulate the relative frequency of cognate words but were unable to do so as they did not find a sufficient number of frequency-unbalanced cognates in Dutch and English. To my knowledge, only one study has examined how frequency-unbalanced cognate words are processed. Cristoffanini et al. (1986) provide evidence that the frequency of cognate words in Spanish influences the processing of English targets in a long-term priming study. More specifically, they found that cognates that were low-frequency in Spanish (e.g., DONACION, with a frequency of 0 per million) were processed more slowly than cognates that were high-frequency in Spanish (e.g., DECADENCIA, with a frequency of 18 per million). The English cognates for these words (DONATION and DECADENCE) had a frequency count of 2 per million. The long term priming paradigm has been criticized, however, due to the likelihood for the emergence of strategic factors.

Another factor to consider when conducting language access studies on cognates is the target language. Most studies on cognates have used the nondominant language as the target language of the experiment based on the questionable assumption that cross-language activation does not emerge when target words are presented in the dominant language (Van Hell & Dijkstra, 2002). This assumption is based on the results from studies by Caramazza and Brones (1979) and Scarborough and Gerard (1989), who tested Spanish-English bilinguals and failed to find a facilitation effect for cognate words presented in the dominant language. Due to the more frequent usage of dominant language words, they are believed to have higher resting levels of activation and can

therefore reach the recognition threshold faster than nondominant language words. It is argued that the processing of the nondominant language can therefore be influenced by the dominant language but not the other way around (Van Hell & Dijkstra). Evidence for the contrary has been provided by Van Hell and Dijkstra who tested Dutch-English-French trilinguals on a lexical decision task in their dominant language (Dutch) and found that response latencies to Dutch-French cognates were faster compared to noncognates. Lemhofer et al. (2004) also provide evidence that is in line with Van Hell and Dijkstra's (2002) proposal that cross language effects are obtained not only when the target language is the nondominant language, but also when it is the stronger language. In Lemhofer et al.'s study, the weakest language impacted the second language. My own extension of Van Hell and Dijkstra's study using English-French bilinguals showed a cognate advantage both when participants were tested in their dominant as well as nondominant languages (Khan & Buchanan, 2008). Furthermore, recent lexical activation studies in bilinguals using experimental paradigms other than single word recognition have also demonstrated the facilitation effect of the nondominant language when participants are tested in their dominant language (e.g., see Titone, Libben, Mercier, Whitford, & Pivneva, 2011 for a study of sentence reading). These results point to the importance of studying cross-language effects in the nondominant as well as the dominant language of bilinguals.

Another factor believed to impact language selectivity is the level of second language proficiency. Van Hell and Dijkstra (2002) tested Dutch-English-French trilinguals in Dutch (L1). They found no facilitation for Dutch-French (L1-L3) cognates when French (L3) proficiency was poor. When another set of trilinguals with a higher

French (L3) proficiency was tested, a clear facilitation was found for cognate words. Thus, cross-language activation of the weaker nontarget language is determined by the level of proficiency in the nondominant language (Van Hell & Dijkstra).

It has been argued that lexical access could be selective or nonselective depending on a number of factors including the experimental task, stimulus list composition, the frequency characteristics of the word, the level of second language proficiency, and whether the task is carried out in the dominant or the nondominant language (Dijkstra, Van Jaarsveld, et al., 1998; Grosjean, 1998, 2001; Lemhofer & Dijkstra, 2004). Other studies investigating the issue of lexical access in more naturalistic contexts such as sentences (as opposed to individual words in the case of lexical decision) have also demonstrated that the degree of lexical activation depends on the sentence context (e.g., Libben & Titone, 2009; Schwartz & Kroll, 2006). Indeed, it has been pointed out that, “it may be dangerous and sometimes simply incorrect to interpret empirical evidence of facilitation or inhibition as a straight-forward reflection of the architecture of the underlying processing system” (Dijkstra, Van Jaarsveld, et al., p. 64).

### **Script Effects**

Researchers have attempted to understand the contribution of semantics, orthography, and phonology in lexical access. Dijkstra, et al. (1999) tested Dutch-English bilinguals on a simple lexical decision task in English on six word types that were based on level of overlap in Dutch and English in semantics (S), orthography (O), and phonology (P). These word types were cognates (SOP = semantic, orthographic, and phonological overlap; SO = semantic and orthographic overlap; SP = semantic and phonological overlap), and interlingual homographs and homophones (OP = orthographic



and phonological overlap; O = orthographic overlap only; P = phonological overlap only). A facilitation effect was found for SOP and SO cognates but not for SP cognates. Also, facilitation was found for the O overlap condition but not for OP. The P overlap condition showed an inhibition effect. These results were interpreted to mean that semantic and orthographic overlap results in facilitation whereas phonological overlap results in inhibition.

Lemhofer and Dijkstra (2004) replicated the study of Dijkstra et al. (1999) but tested cognates (SOP, SO, SP) and interlingual homographs and homophones (OP, O, P) in separate experiments in order to test if list composition plays a role. In addition, they investigated the role of task demands by conducting generalized lexical decision tasks on the same stimulus lists. In the simple lexical decision task, like Dijkstra et al. (1999) they obtained a facilitatory effect for SOP and SO cognates but not for SP cognates. Further, like Dijkstra et al. they obtained a facilitatory effect for the O and not for OP condition. Unlike Dijkstra et al., however, they did not obtain an inhibitory effect for the P condition. In the generalized lexical decision task, they found that interlingual homographs (O and OP) were recognized faster than English control words but had the same response latencies as Dutch control words. For the P items, no difference was obtained in reaction times compared to control words. Further, they found that orthographically identical cognate words (SOP and SO) were recognized faster than English and Dutch control words. For the SP condition, they noted that there was no difference in reaction times compared to the control words. The differences in the results for the language specific lexical decision task and the generalized lexical decision for the same interlingual homographs may be due to the difference in task demands and the

difference in the time-course of activation of words from the dominant and nondominant languages (Dijkstra, 2005). Further, Lemhofer and Dijkstra (2004) proposed that the inhibition for the P condition in Dijkstra et al.'s study may be due to a lack of control in matching of the test and control items as this effect was seen in monolinguals (see Jared & Kroll, 2001 for a similar explanation). They proposed that while cross-linguistic orthographic and semantic overlap leads to facilitation, the role of phonological overlap is unclear and requires further investigation. However, the absence of facilitation for the SP condition obtained in this study as well as the study by Dijkstra et al. (1999) was in contrast to the findings obtained by Gollan et al. (1997), Kim and Davis (2003), and Voga and Grainger (2007) who all obtained a facilitation effect for cross-script cognates (semantic and phonological overlap). While the contrasting findings may be due to the fact that the experimental paradigm used by these authors was masked priming and not a simple lexical decision task, it could also be due to the use of cross-script cognates.

The simple lexical decision task studies presented above have all been conducted in same-script languages such as Dutch-English, French-English, and Spanish-English. A study by Font (2001, as in Dijkstra, 2005) showed that neighbour cognates, that is, cognates that differ in one letter show a facilitation effect but this effect is smaller than that for identical cognates. The degree of orthographic overlap is thus believed to impact the level of cross-language activation. One of the models of visual word recognition that accounts for this finding is the Bilingual Interactive Activation model.

The Bilingual Interactive Activation (BIA) model (Dijkstra & Van Heuven, 1998; Van Heuven et al., 1998) is a visual word recognition model that assumes language access to be non-selective and also an integrated lexicon for the two languages. In this

model the four representational levels, letter features, letters, words, and language nodes, are organized in a hierarchical manner with excitatory and inhibitory connections existing both within and between levels. In a word recognition task, when a target word is presented the letter features corresponding to the input are activated, which in turn activate the letters of which they are a part. The letters activate the words which contain them and the words in turn activate the language nodes. Inhibition is also a feature of this model such that words and letters that are not a part of the presented stimulus are inhibited. Further, activated language nodes inhibit nodes in the other language. Finally, the lexical candidate that matches the presented word becomes the most highly activated unit (Dijkstra, 2005; Dijkstra & Van Heuven, 2002). Word frequency and language proficiency are both believed to influence the resting level of activation of the words from different languages. However, this model does not account for phonological and semantic representations. Further, it does not sufficiently explain task effects nor the representation of interlingual homographs and cognates (Dijkstra; Dijkstra & Van Heuven). Thus, the BIA+ was proposed in order to account for these.

The BIA+ model includes phonological and semantic codes which are activated by the activated orthographic word candidates (Dijkstra & Van Heuven, 2002). The semantic level is between the word and the language node level and cognate words in this model have a shared semantic representation but separate representations at the word level (Sanchez-Casas & Garcia-Albea, 2005). The cognate facilitation effect is explained in this model in the following way: upon presentation of a specific stimulus the activation of the orthographic codes proceeds in the same manner as described for the BIA model and is initially non-selective. The degree of overlap between the input and the

representation in the lexicon determines the degree of activation of the internal representation. Thus, when an orthographically identical cognate word is presented the orthographic representations in both the languages are activated simultaneously due to the complete match. The shared semantic representation is subsequently activated by combined feed-forward activation from the two activated orthographic units. The activated semantic representation in turn sends feedback to the two orthographic representations amplifying their level of activation (Lemhofer & Dijkstra, 2004). The orthographic unit representing the cognate word reaches the recognition threshold sooner than would be the case for the orthographic unit corresponding to the noncognate word resulting in a cognate advantage over noncognate words (Lemhofer & Dijkstra). For nonidentical cognates (e.g., the French pair cognate pair LAKE-LAC), the model predicts that when the stimulus word is presented there is activation in both the orthographic units but the degree of activation for the nonidentical orthographic unit is less than that for the identical unit. Thus, a smaller degree of orthographic overlap within cognate pairs will lead to lower levels of semantic activation and feedback and longer response latencies for nonidentical cognate pairs. It has been proposed that facilitation is “a linear function of the degree of orthographic overlap” (Lemhofer and Dijkstra, 2004, p. 546). When the two languages do not share a common script at all (e.g. Chinese and English), this model predicts that the lexical candidates of the cross script language that do not share orthographic features of the input stimulus, will not be activated (Dijkstra & Van Heuven). While phonological overlap may still lead to activation of phonological codes of the nontarget language, for cross script languages the nontarget language will not be activated to a great degree and experiments conducted with these will result in support for

language specific access (Dijkstra & Van Heuven). To my knowledge, there are no studies that have examined the cognate facilitation effect in cross-script languages using the simple lexical decision paradigm that has been used by the majority of the studies presented above.

### **Rationale for the Study**

Despite the shift in recent years towards more comprehensive models of bilingual language representation and processing (Kroll & Tokowicz, 2005), gaps exist in the literature. For example, few studies have addressed how language processing is affected by intrinsic differences between languages. The majority of studies on bilingual processing and representation have been done on bilinguals whose two languages share a similar script such as French-English, Spanish-English, or Dutch-English. Language combinations such as Chinese-English, Arabic-English, and Urdu-English that have substantial script differences have not been studied to a comparable extent and this has resulted in Eurocentric models of bilingualism. It remains to be seen how models of bilingual lexical representation and access will incorporate the largely neglected languages. It is also interesting to note that cultural differences between the two languages of the bilingual are more likely to emerge when both languages do not have a European origin. These cultural differences may manifest themselves in different frequencies of word usage across the two languages of the bilingual. For example, the English-French translation pair *garlic-ail* has a frequency of 5 occurrences per million in English (Durda and Buchanan, 2006) and 1 occurrence per million in French (Baudot, 1992). The Urdu translation لہسن on the other hand, has a frequency of 82 occurrences per million (Khan & Buchanan, 2006). While garlic is a basic ingredient in South Asian

recipes, this is not the case for countries in which English and French are the indigenous languages. This cultural difference in word usage may account for the difference in written word frequency.

Previous research with monolinguals has established that word frequency is the strongest predictor of reaction times in the lexical decision task (e.g., Allen, McNeal, & Kvak, 1992; Gordon, 1983; Monsell et al., 1989; Paap, McDonald, Schvaneveldt, & Noel 1987) and most monolingual models of word recognition have incorporated frequency sensitive processes (e.g., Balota & Chumbley, 1984; Forster, 1976; McClelland & Rumelhart, 1981; Morton, 1969; Seidenberg & McClelland, 1989). In fact, the adjudication of the adequacy of these models is based, in large part, upon their ability to explain this ubiquitous effect.

Research with bilinguals has also shown the large effect of word frequency. De Groot (1992b) showed that word frequency is the most important variable along with cognate status, that effects the way in which bilinguals process words. De Groot, Borgwaldt, Bos, and Van Den Eijnden (2002) also showed that frequency variables were the strongest predictors of reaction time in the lexical decision task. Given the enormous impact of word frequency on word processing, the role of word frequency cannot be neglected in studies on the processing and representation of languages. Altarriba and Basnight-Brown (2007) presented a review of bilingual semantic and translation priming studies and noted that several studies failed to provide information on whether word frequency of the stimuli used was monitored (e.g., De Groot & Nas, 1991) and some failed to control for this variable (e.g. Chen & Ng, 1989). Kim and Davis (2003) have proposed that differences in the frequency of the word stimuli used across studies may be

responsible for the lack of convergence in findings (e.g., Kim & Davis, 2003; Gollan et al., 1997; Voga & Grainger, 2007). The role of this important variable needs to be examined in bilingual research.

### **Current Goals**

The first goal of this study is to examine if the cognate advantage obtained for same script languages in the simple lexical decision task will also be obtained for a language pair that does not share a script. In Experiment 1, Urdu-English bilinguals will be tested on a simple lexical decision task both in their L1 and in L2. If lexical access is non-selective for languages with different scripts, a cognate facilitation effect would be obtained. It is expected that this effect will be obtained for low-frequency cognate words both when the target word is presented in L1 and when it is presented in L2. For high-frequency cognate words, the cognate facilitation effect may not be seen as the stronger frequency effect may prevent the weaker cognate effect from emerging.

While frequency-unbalanced homographs have been used to study the nature of language access, previous attempts to study cognate words with different frequency of word usage in the two languages of the bilingual for the same word have been unsuccessful. Dijkstra, Van Jaarsveld, et al. (1998) attempted to study Dutch-English bilinguals using unbalanced cognate words. However, they were unable to find a sufficient number of frequency-unbalanced cognate words and reasoned that these word items are rare “due to the similarity of the larger cultural contexts in which English and Dutch are used” (Dijkstra, Van Jaarsveld et al., p. 53). In an earlier study it was found that frequency differences exist even among cognate words in Urdu and English most likely due to the differences in cultural contexts in which these languages are used (Khan

& Buchanan, 2006). This makes the Urdu-English language combination particularly interesting as it allows for the investigation of word type frequency effects within cognates. The second goal of this study is to examine how frequency-unbalanced cognates are accessed and represented in the bilingual lexicon. Towards this end, Experiment 1 will also examine how frequency unbalanced cognate words are processed within the simple lexical decision task. If lexical access is selective, reaction times to target words should not be influenced by the frequency of their cognate translations.

The third goal of this study is to examine whether the difference in findings of Kim and Davis (2003), Gollan et al. (1997), and Voga and Grainger (2007) in terms of the magnitude of the cognate and noncognate priming effect can be attributed to frequency differences in the word stimuli as proposed by Kim and Davis. In order to do this, the masked priming study by Gollan et al. will be replicated in Experiment 2. However, unlike Gollan et al., both low-frequency and high-frequency cognate and noncognate prime-target pairs will be presented. According to Kim and Davis target word frequency plays a role in processing, and whether phonological or semantic activation would lead to priming. According to their proposal, for low-frequency target words a larger cognate priming effect should be obtained relative to the noncognate priming effect due to the greater reliance on phonology. For high-frequency target words the size of the cognate and noncognate priming effects should not be different. Additionally, a priming asymmetry should be observed such that when primes are presented in L1 and targets in L2, both a cognate and a noncognate priming effect should be obtained and this should not be the case for L2 primes followed by L1 targets. Further, as frequency-unbalanced cognate and noncognate words have not been



investigated previously in a masked priming paradigm, in Experiment 2 the processing and representation of these words in the Urdu-English bilingual lexicon will be examined.

## **CHAPTER II**

### **Experiment 1**

#### **Lexical Decision in English and Urdu Using Balanced and Unbalanced Cognates and Noncognates**

##### **Method**

##### **Participants**

Thirty five Urdu-English bilinguals participated in this experiment. They were students at a post-secondary educational institution in Karachi, Pakistan and were recruited by word of mouth. They received monetary compensation for participation, specifically, the equivalent of CAD \$10 in Pakistani Rupees. All participants were native speakers of Urdu and learned English early in life. All had normal or corrected-to-normal vision.

##### **Material and Apparatus**

The experimental stimuli were selected such that four frequency categories were formed for the cognate and noncognate words using different combinations of word form frequencies in Urdu and English. Urdu frequency counts were derived from a database constructed previously (Khan & Buchanan, 2006). English frequency counts were based on the Wordmine database (Durda & Buchanan, 2006). The four frequency categories were: high-frequency Urdu and high-frequency English (HFU-HFE), low-frequency Urdu and low-frequency English (LFU-LFE), high-frequency Urdu and low-frequency

English (HFU-LFE), and low-frequency Urdu and high-frequency English (LFU-HFE). Each of these categories consisted of twenty items. Half of these items were cognates and the other half were noncognates.

Low-frequency words were defined as those that had an orthographic frequency of up to 11 per million. High-frequency words had an orthographic frequency of 40 or more per million. The mean frequency and word length in syllables for each of the conditions is presented in Table 1. The cognate and noncognate word lists were as closely matched as possible on frequency (and log frequency) and word length. There was no difference in the log frequency values of cognates and noncognates for each condition as indicated by a series of t-tests (all  $t$ s < 1.85 and all  $p$ s > 0.05). Further, a series of t-tests indicated that there was no difference in the word length of cognates and noncognates for each condition (all  $t$ s < 1.15 and all  $p$ s > 0.05) with one exception. In the LFU-LFE condition the low-frequency English cognates had a greater word length than the low-frequency English noncognates,  $t(9) = 2.45$ ,  $p < 0.05$ . However, as the greater word length of the cognate words would decrease rather than increase the likelihood of finding a cognate facilitation effect, the presence of an effect would be strong evidence of cognate facilitation. All words were nouns and the experimenter evaluated words for concreteness, selecting those that were most concrete. Obscure and archaic words were excluded. English nonwords were created by using words that matched the stimulus words in length, bigram frequency, and orthographic neighbourhood. A letter was changed in each of these words to create orthographically and phonologically legal nonwords. Urdu nonwords were also created by changing a letter in each word on another list of Urdu words to obtain orthographically and phonologically legal nonwords.

Table 1

*Mean word length in number of syllables for English (WLE) and Urdu (WLU) and log frequency in English (WFE) and Urdu (WFU) for cognates and noncognates in Experiment 1.*

Frequency Categories	Word Type							
	Cognates				Noncognates			
	WLU	WLE	WFU	WFE	WLU	WLE	WFU	WFE
HFU-HFE	1.60	1.60	2.09	2.09	1.30	1.30	2.13	2.05
HFU-LFE	1.70	1.70	2.01	0.13	1.70	1.70	1.93	0.39
LFU-HFE	1.60	1.50	0.74	2.17	1.80	1.20	0.31	2.05
LFU-LFE	2.00	2.00	0.53	0.37	1.90	1.60	1.13	0.60

The words and nonwords were presented in random order in a single block for each of the target languages. A total of 80 words and 80 nonwords were presented in each language (see Appendix A for the stimulus set). Another set of eight words and eight nonwords were used for the practice trial.

Participants were tested using a Compaq Presario 1500 laptop. All stimuli were presented in the center of the screen in black against a white background. The Urdu stimuli were presented in 72 point Nafees Naksh font, while the English stimuli were presented in 42 point Times New Roman font. These font sizes were used to ensure that the Urdu and English stimuli were approximately equal in size. The participants' responses were recorded using the Direct RT software (Jarvis, 1999). Viewing distance was approximately 60 cm.

### **Procedure**

Participants were tested individually over two sessions: one with English target words and the other with Urdu target words. The order of presentation of the English and Urdu sessions was alternated between participants and testing was carried out with a gap of at least two days between the two experimental sessions. Instructions were given at the beginning of each session, which were in the same language as the target words for that session. Participants were asked to determine as quickly and accurately as possible, if the presented letter strings were real words or not. The items appeared in random order in the center of the computer screen separated by a delay. They pressed the “/” key if the presented string was a word and the “Z” key if it was not a word. The RT was measured from the onset of the stimulus to when the subject pressed the response button. After

each response, the stimulus was cleared from the screen and the stimulus from the next trial appeared on the screen. Sixteen practice trials were presented first, followed by 160 experimental trials. Participants completed a reading proficiency test in Urdu before completing the lexical decision task with Urdu targets and a similar test in English before completing the lexical decision task in English. These tests required the participants to read a passage in each language (see Appendix B) for a period of one minute and the number of words read and errors made were recorded in order to evaluate proficiency. The English passage was an abstract from the book, “Alice in Wonderland” by Lewis Carroll, and was at the Grade 6 reading level. The Urdu passage was an abstract from a short story called “Taj Mahal”, and was also at the Grade 6 reading level. After completing the lexical decision task in the first session, the participants completed a language background questionnaire in English (see Appendix C). In this questionnaire they were asked to assess their proficiency in speaking, listening, reading, and writing in both their languages.

### **Results**

After the completion of the experiment, one of the participants reported that her first language was Gujrati (one of the languages spoken in Pakistan). Another participant reported having a reading disability. A third participant reported that he had never received formal instruction for reading Urdu. The data from these participants was excluded from the analysis. Two of the participants made more than 20% errors (averaged across the English and Urdu target conditions) and their data were also

discarded. Thus, data from thirty participants formed the basis of the analysis in this experiment. The results from the item analysis are presented in Appendix D.

### **Language Fluency**

A series of paired sample t-tests indicated that reading proficiency for participants in Experiment 1, as indicated by the number of words read within a specified period of time, was higher for English than for Urdu,  $t(29) = 9.213$   $p < 0.05$ . There was no difference in the number of errors made across the two languages on the reading task,  $t(29) = 1.114$ ,  $p = 0.274$ . Self-reported language proficiency averaged across the domains of speaking, comprehension, reading, and writing was also higher for English than for Urdu,  $t(29) = 2.291$ ,  $p < 0.05$  (see Table 2 for a summary of the results from the Language Questionnaire). In addition, informal observation of the participants also suggested that English was the dominant language for these participants.

Table 2

*Language History (Scale 1=Only Urdu, 2=Urdu > English, 3=Urdu=English, 4=English>Urdu; 5=Only English) and Self-assessed Urdu and English Proficiency Ratings (From 1=Nonfluent to 7=Native Fluency) for Experiment 1.*

Proficiency Measure	Minimum	Maximum	Mean
<hr/>			
Proficiency (1-7)			
Urdu			
Speaking	4	7	5.88
Comprehension	1	7	5.33
Reading	2	7	5.20
Writing	1	7	5.17
English			
Speaking	2	7	5.80
Comprehension	2	7	5.83
Reading	4	7	6.17
Writing	3	7	6.13
Language Use (1-5)			
Speaking	1	4	2.97
Listening	2	5	3.33
Reading	3	5	4.10
Writing	3	5	4.07
Age of Acquisition (years old when began acquiring language)			
Urdu	0	6.50	1.18
English	0	6.50	3.24
<hr/>			

## **Data Treatment**

Data from the English and Urdu target conditions were treated separately. For the English target condition, after removing incorrect responses (8.80% of data), lower and upper absolute cut-off limits were set at 200ms and 2000ms, respectively. This resulted in removal of 1.42% of the data. Reaction times greater than two standard deviations above and below the mean for each condition for each participant were replaced with the appropriate cut-off value. This treatment was applied to 4.38% of the data. Mean lexical decision times were subsequently calculated for each of the conditions and this data is presented in Table 3. For the Urdu target condition, after removing incorrect responses (11.04% of data), lower and upper absolute cut-off limits were set at 200ms and 2000ms respectively. This resulted in removal of 6.33% of the data. Reaction times greater than two standard deviations above and below the mean for each condition for each participant were replaced with the appropriate cut-off value. This treatment was applied to 2.42% of the data. Mean lexical decision times were subsequently calculated for each of the conditions and this data is also presented in Table 3.

## **Subject Analysis**

**Reaction Time.** A four-way repeated measures ANOVA was carried out, which consisted of the following variables: Language (English versus Urdu), Status (cognate versus noncognate), English Frequency (high versus low), and Urdu Frequency (high versus low). The ANOVA statistics are presented in Table 4. However, of particular interest is the cognate effect (i.e., mean RT to noncognate words minus the mean RT to



Table 3

*Mean lexical decision times in milliseconds and percentage Error Rates (in brackets) for English and Urdu for each of the conditions in Experiment 1.*

Frequency Categories	Word Type			
	Cognates		Noncognates	
	English	Urdu	English	Urdu
HFU-HFE	622.54 (1.00)	830.2 (5.67)	593.65 (2.00)	809.07 (3.00)
HFU-LFE	817.29 (34.67)	867.8 (5.00)	766.14 (13.00)	908.14 (4.67)
LFU-HFE	630.09 (1.00)	1000.63 (18.33)	654.84 (4.00)	1028.67 (30.00)
LFU-LFE	704.25 (8.67)	1042.46 (13.33)	760.17 (6.00)	1079.97 (8.33)

Table 4

*The Results of 2 (Language: English Vs. Urdu) x 2 (Status: Cognate Vs. Noncognates) x 2 (English Frequency: High Vs. Low) x 2 (Urdu Frequency: High Vs. Low) Repeated Measures Analysis of Variance for Experiment 1 (Subject Analysis).*

Effect	Reaction Time			Error Rate		
	<i>df</i>	<i>F1</i> value	<i>p</i> value	<i>df</i>	<i>F2</i> value	<i>p</i> value
Main Effect						
Language	(1,29)	49.83	<0.05	(1,29)	3.81	=0.06
Status	(1,29)	1.44	=0.24	(1,29)	2.58	=0.12
English Frequency	(1,29)	81.81	<0.05	(1,29)	18.26	<0.05
Urdu Frequency	(1,29)	44.71	<0.05	(1,29)	9.43	<0.05
Two-Way Interaction						
Language x Status	(1,29)	2.66	=0.11	(1,29)	5.19	<0.05
Language x English Frequency	(1,29)	18.71	<0.05	(1,29)	99.08	<0.05
Language x Urdu Frequency	(1,29)	81.69	<0.05	(1,29)	93.50	<0.05
Status x English Frequency	(1,29)	1.12	=0.30	(1,29)	36.67	<0.05
Status x Urdu Frequency	(1,29)	8.74	<0.05	(1,29)	22.99	<0.05
English Frequency x Urdu Frequency	(1,29)	12	<0.05	(1,29)	117.06	<0.05
Three-Way Interaction						
Language x Status x English Frequency	(1,29)	0.92	=0.35	(1,29)	3.03	=0.09
Language x Status x Urdu Frequency	(1,29)	2.21	=0.15	(1,29)	3.834	=0.06
Language x English Frequency x Urdu Frequency	(1,29)	6.48	<0.05	(1,29)	1.19	=0.29
Status x English Frequency x Urdu Frequency	(1,29)	0.001	=0.98	(1,29)	0.11	=0.74
Four-Way Interaction						
Language x Status x English Frequency x Urdu Frequency	(1,29)	2.67	=0.96	(1,29)	28.10	<0.05

Note. *F1* = Reaction Time; *F2* = Error Rate

Table 5

*The Results of the Paired Sample T-Tests Examining the CFE for Experiment 1.*

Language	English Frequency	Urdu Frequency	Subject Analysis				Error Analysis			
			M Diff. (ms)	df	t value	p value	M Diff.(%)	df	t value	p value
English	High	High	-28.90	29	-2.11	<0.05	1.00	29	1.00	=0.33
	Low	Low	55.93	29	2.48	<0.05	2.67	29	1.31	=0.20
	High	Low	24.75	29	1.74	=0.92	3.00	29	3.53	<0.05
	Low	High	-51.16	29	-2.45	<0.05	21.67	29	-4.50	<0.05
Urdu	High	High	-21.13	29	-0.95	=0.35	2.66	29	-1.09	=0.28
	Low	Low	37.51	29	1.62	=0.12	5.00	29	-1.70	=0.10
	High	Low	28.04	29	0.78	=0.44	11.67	29	3.19	<0.05
	Low	High	40.33	29	1.42	=0.17	0.33	29	-1.62	=0.87

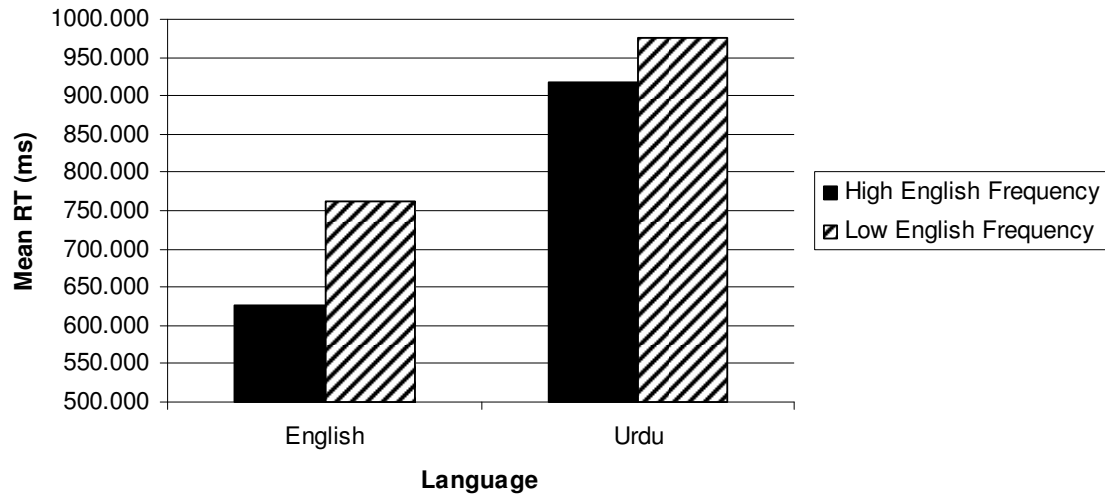
Note. CFE (Cognate Facilitation Effect) = RT for Noncognates - RT for Cognates;

M Diff. = Mean Difference

cognate words) in each of the frequency conditions as this will indicate the degree of cross-language activation. These planned comparisons are presented in Table 5.

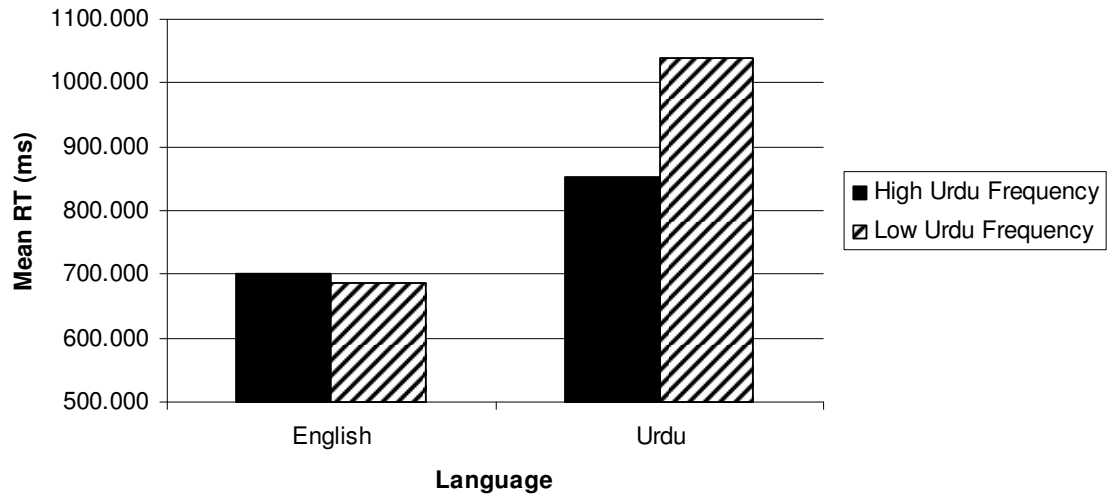
**Analysis of variance.** There was a main effect for Language, such that English target words were recognized faster ( $M = 693.61$  ms) than Urdu target words ( $M = 945.87$  ms). There was no main effect for Status. There was a main effect for English Frequency, such that high-frequency English targets or Urdu targets with high-frequency English translations were responded to faster ( $M = 771.21$  ms) than low-frequency English targets or Urdu targets with low-frequency English translations ( $M = 868.28$  ms). There was a main effect for Urdu Frequency, such that high-frequency Urdu targets or English targets with high-frequency Urdu translations were responded to faster ( $M = 776.86$  ms) than low-frequency Urdu targets or English targets with low-frequency Urdu translations ( $M = 862.63$  ms).

There was an interaction between Language and English Frequency. This indicates that mean latencies for English and Urdu target words varied depending on the English Frequency of these words. Simple effects analysis revealed that when the target language was English, high-frequency English words were responded to faster than low-frequency English words,  $F(1, 29) = 92.69, p < 0.05$ . When the target language was Urdu, words with high-frequency English translations were still responded to faster than words with low-frequency English translations, but the difference in RT was not as large,  $F(1, 29) = 16.80, p < 0.05$ . This interaction is shown in Figure 1.



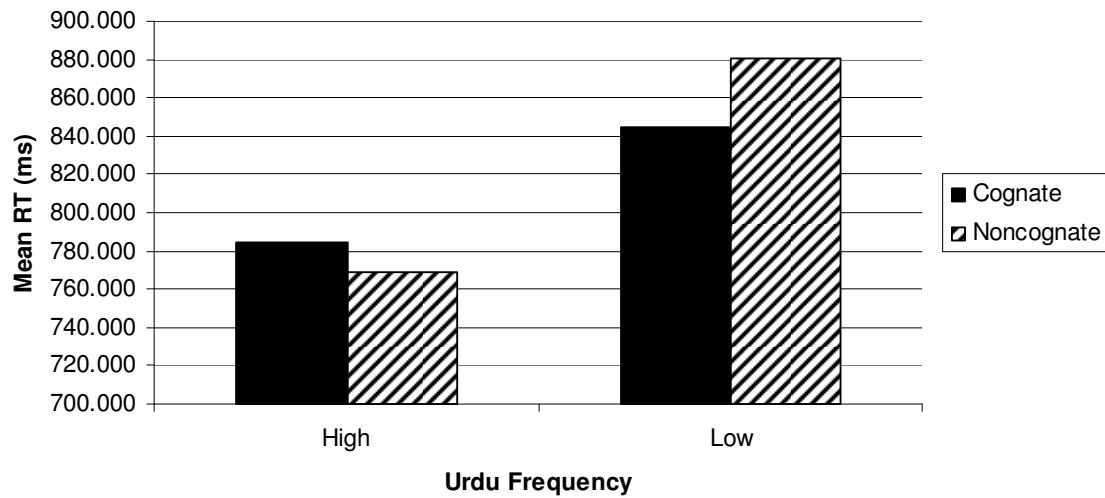
*Figure 1.* Mean reaction time in milliseconds for words presented in each of the Languages (English and Urdu) as a function of English Frequency (high and low).

There was also an interaction between Language and Urdu frequency. This indicates that mean latencies for English and Urdu target words varied depending on the Urdu Frequency of the words. Post hoc simple effects analysis revealed that high-frequency Urdu target words were responded to faster than low-frequency Urdu target words,  $F(1, 29) = 72.83, p < 0.05$ . However, when the target language was English, there was no difference in RTs between words with high-frequency Urdu translations and those with low-frequency Urdu translations,  $F(1, 29) = 1.53, p = 0.22$ . This interaction is shown in Figure 2.



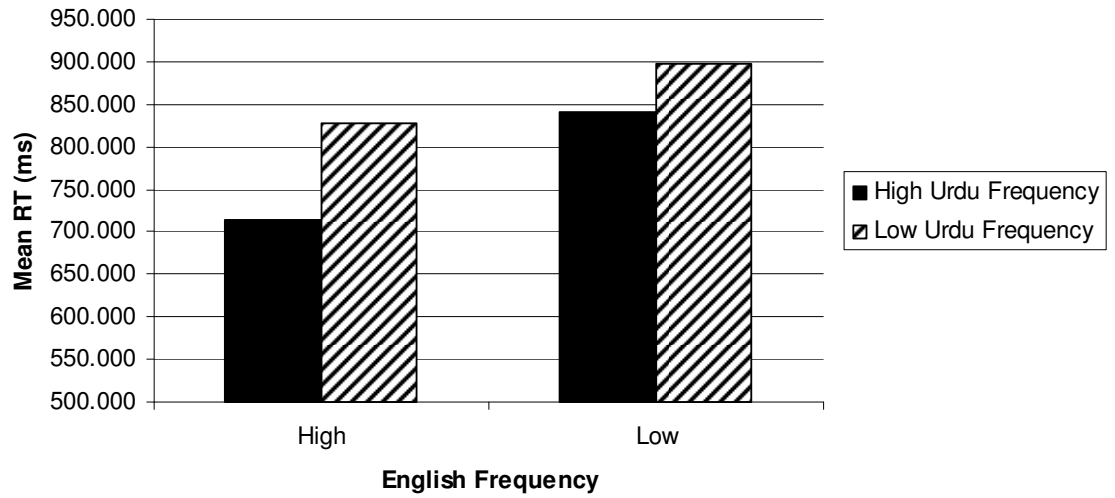
*Figure 2.* Mean reaction time in milliseconds for words presented in each of the Languages (English and Urdu) as a function of Urdu Frequency (high and low).

There was an interaction between Status and Urdu Frequency. Post hoc simple effects analysis revealed that RTs to high-frequency Urdu cognates were similar to RTs to high-frequency Urdu noncognates,  $F(1, 29) = 1.80, p = 0.19$ . However, low-frequency Urdu cognates were responded to faster than low-frequency Urdu noncognates,  $F(1, 29) = 7.3, p < 0.05$ . This interaction is shown in Figure 3.



*Figure 3.* Mean reaction time in milliseconds for cognate and noncognate words as a function of Urdu Frequency (high and low).

There was also an interaction between English Frequency and Urdu Frequency. Post hoc simple effects analysis revealed that RTs for words which had a high-frequency in both Urdu and English were faster than for words which had a high-frequency in English only,  $F(1, 29) = 57.42, p < 0.05$ . This difference in RTs was smaller for words with high-frequency in Urdu and low-frequency in English and words with low-frequency in Urdu and low-frequency in English,  $F(1, 29) = 13.51, p < 0.05$ . This interaction is shown in Figure 4.



*Figure 4.* Interaction graph for English Frequency and Urdu Frequency.

There was also a three-way interaction between Language, English Frequency, and Urdu Frequency. Figure 5 shows that when the target language was English, the RTs for high- and low-frequency English words were not impacted much by their Urdu Frequency. However, when the target language was Urdu, RTs to high- and low-frequency Urdu words differed based on the English Frequency of the words.



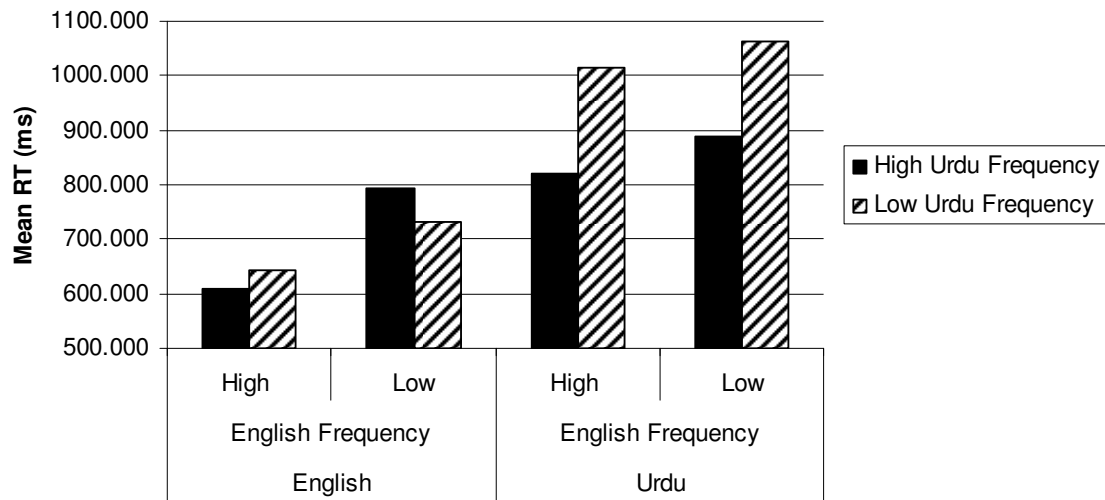


Figure 5. Interaction graph for Language, English Frequency, and Urdu Frequency.

There were no other two-way, three-way, or four-way interactions.

**Planned comparisons.** A series of Paired Sample t-tests was conducted.

*Frequency-balanced translation pairs.* There was a cognate effect for high-frequency English words with high-frequency Urdu translations where cognates were responded to *slower* than noncognates. There was also a cognate effect for low-frequency English words with low-frequency Urdu translations where cognates were recognized *faster* than noncognates. There were no cognate effects when the target language was Urdu. This information is presented in Figures 6 and 7.

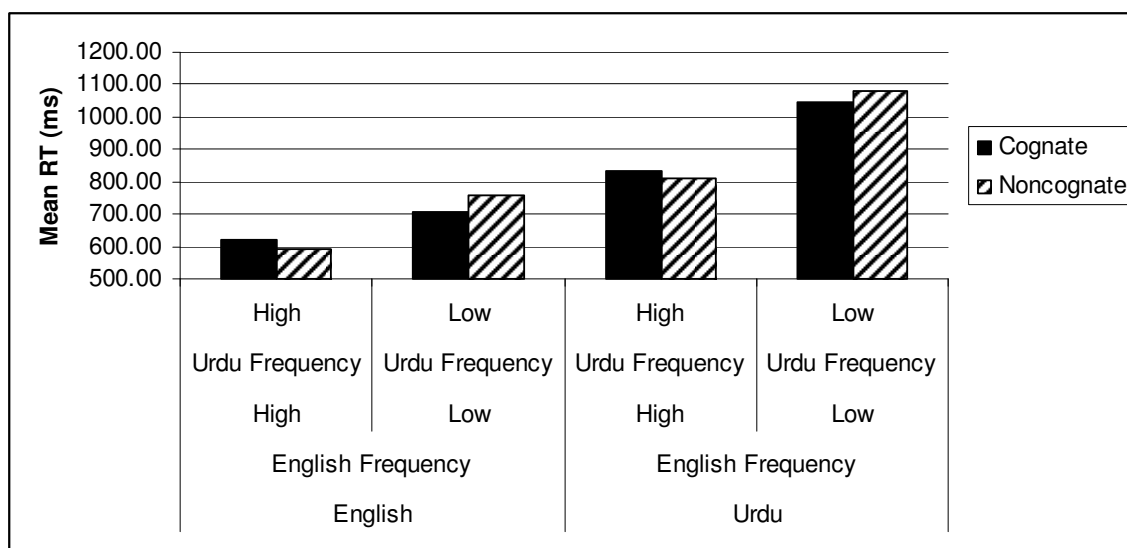


Figure 6. Mean reaction time graph for cognates and noncognates for the frequency-balanced condition for English and Urdu.

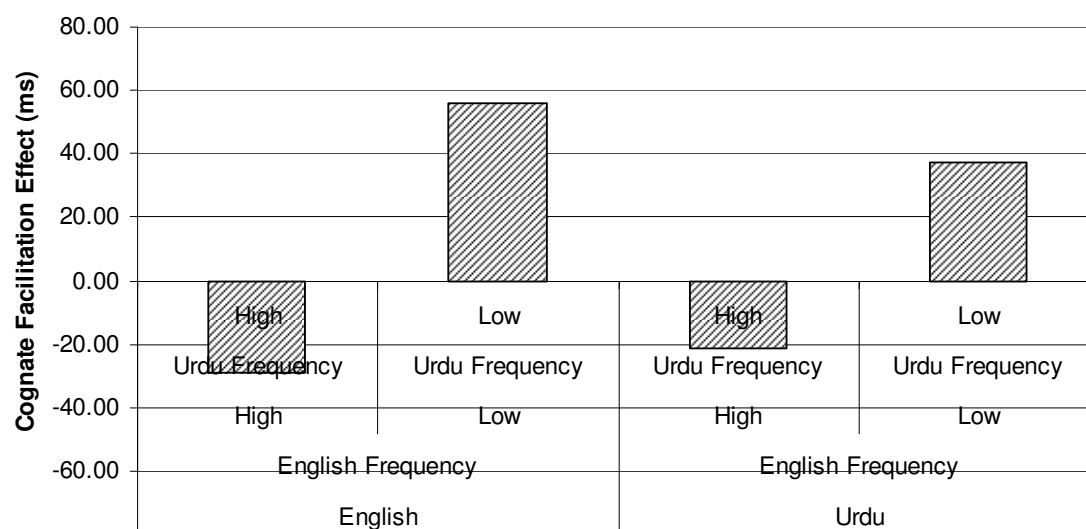
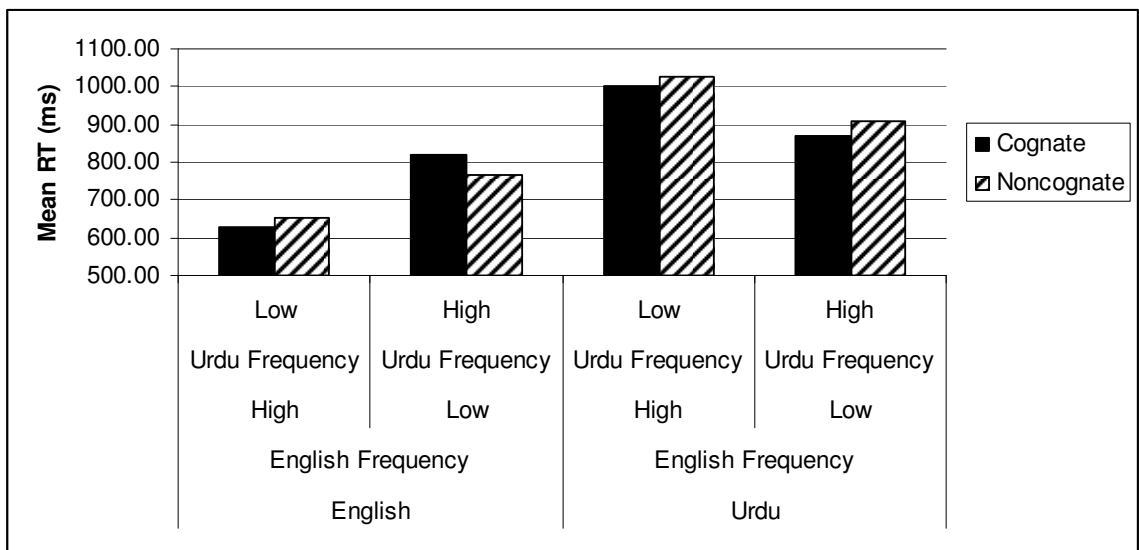


Figure 7. Cognate effect (ms) in English and Urdu for the frequency-balanced condition.

*Frequency-unbalanced translation pairs.* There was no cognate effect for high-frequency English words with low-frequency Urdu translations. However, there was a cognate effect for low-frequency English words where items with high-frequency Urdu translation were responded to *slower* than noncognates. There were no cognate effects when the target language was Urdu. This information is presented in Figures 8 and 9.



*Figure 8.* Mean reaction time graph for cognates and noncognates for the frequency unbalanced condition for English and Urdu.

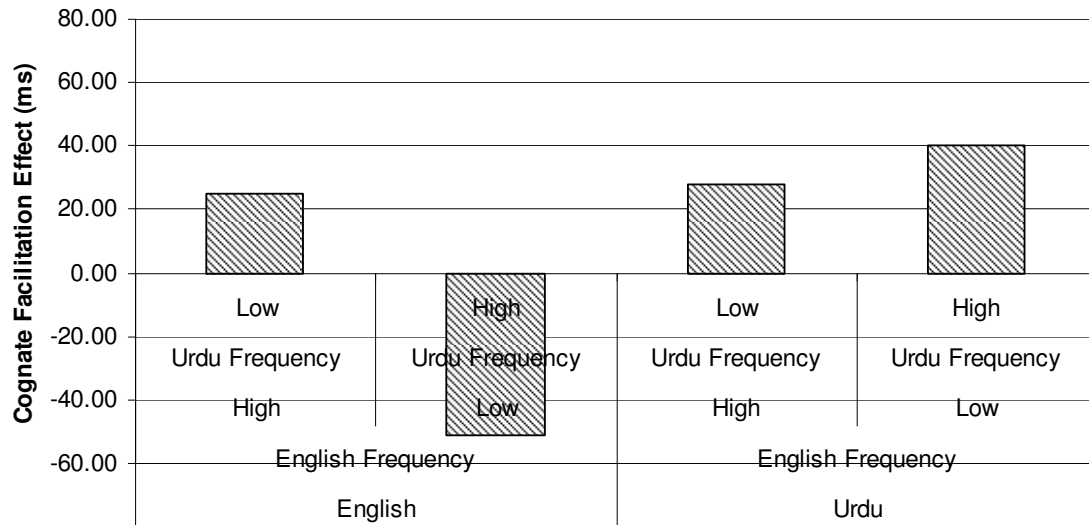


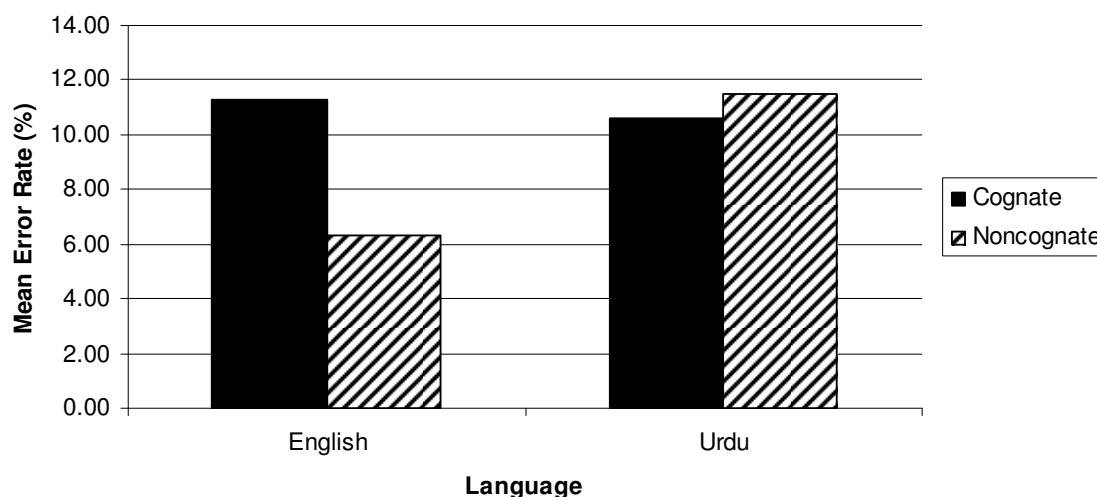
Figure 9. Cognate effect (ms) in English and Urdu for the frequency unbalanced condition.

**Error Rate.** Mean error rates were calculated for English and Urdu for each of the conditions and this data is presented in Table 3. A four-way ANOVA was carried out, which consisted of the following variables: Language (English versus Urdu), Status (cognate versus noncognate), English Frequency (high versus low), and Urdu Frequency (high versus low). The ANOVA statistics are presented in Table 4. Again, of particular interest is the cognate effect (i.e., mean Error Rate to noncognate words minus the mean Error Rate to cognate words) in each of the frequency conditions as this will indicate the degree of cross-language activation. These planned comparisons are presented in Table 5.

**Analysis of Variance.** The main effect for Language approached significance with English words being recognized with greater accuracy than Urdu words. There was

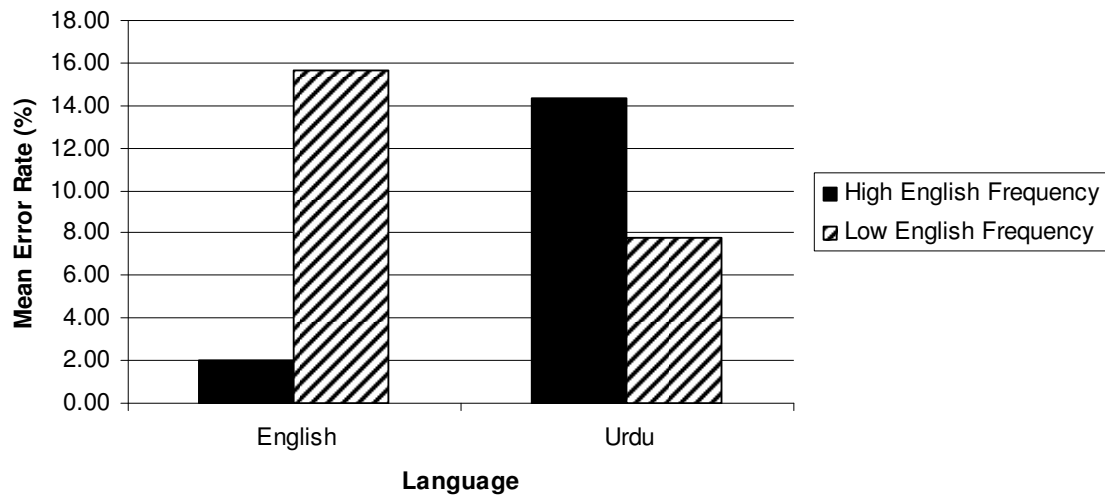
no main effect for Status. There was a main effect of English Frequency, such that high-frequency English targets or Urdu words with high-frequency English translations were recognized more accurately than low-frequency English targets or Urdu words with low-frequency English translations. There was a main effect of Urdu Frequency, such that high-frequency Urdu targets or English targets with high-frequency Urdu translations were recognized more accurately than low-frequency Urdu targets or English targets with low-frequency Urdu translations.

There was an interaction between Language and Status. Post hoc simple effects analysis revealed that when the target language was English, fewer errors were made for noncognate words than for cognate words,  $F(1, 29) = 11.35, p < 0.05$ . On the other hand, when the target language was Urdu there was no difference in the error rate for cognate and noncognate words,  $F(1, 29) = 0.18, p = 0.67$ . This interaction is shown in Figure 10.



*Figure 10.* Mean percentage Error Rate in each of the languages tested as a function of cognate status (cognate vs. noncognate).

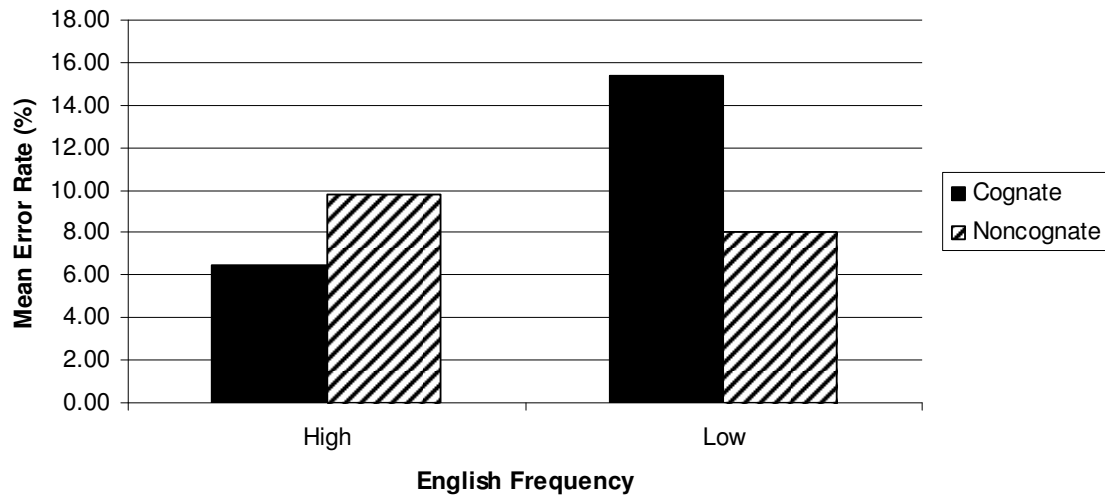
There was also an interaction between Language and English Frequency. Post hoc simple effects analysis showed that when English was the target language, fewer errors were made for high-frequency English words than for low-frequency English words,  $F(1, 29) = 73.10, p < 0.05$ . However, when the target language was Urdu, more errors were made when the English Frequency of the words was high than when it was low,  $F(1, 29) = 45.72, p < 0.05$ . This interaction is shown in Figure 11.



*Figure 11.* Mean percentage Error Rate for each of the languages tested as a function of English Frequency (high vs. low).

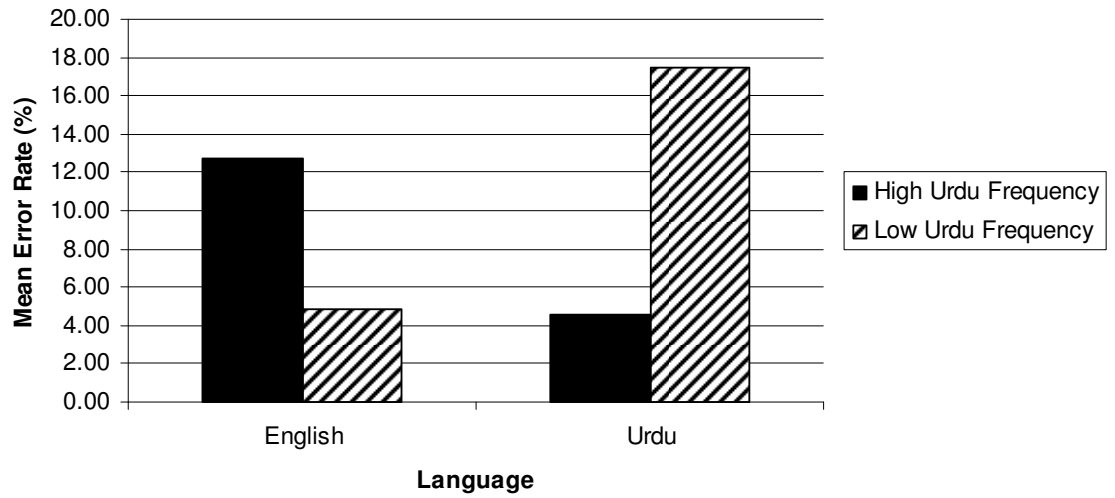
There was an interaction between Status and English Frequency. Post hoc simple effects analysis showed that fewer errors were made to cognate words than to noncognate words when the English Frequency was high,  $F(1, 29) = 5.921, p < 0.05$ . On the other

hand, more errors were made to cognate than to noncognate words when the English Frequency was low,  $F(1, 29) = 17.52, p < 0.05$ . This interaction is shown in Figure 12.



*Figure 12.* Mean percentage Error Rate for cognate and noncognate words as a function of English Frequency (high vs. low).

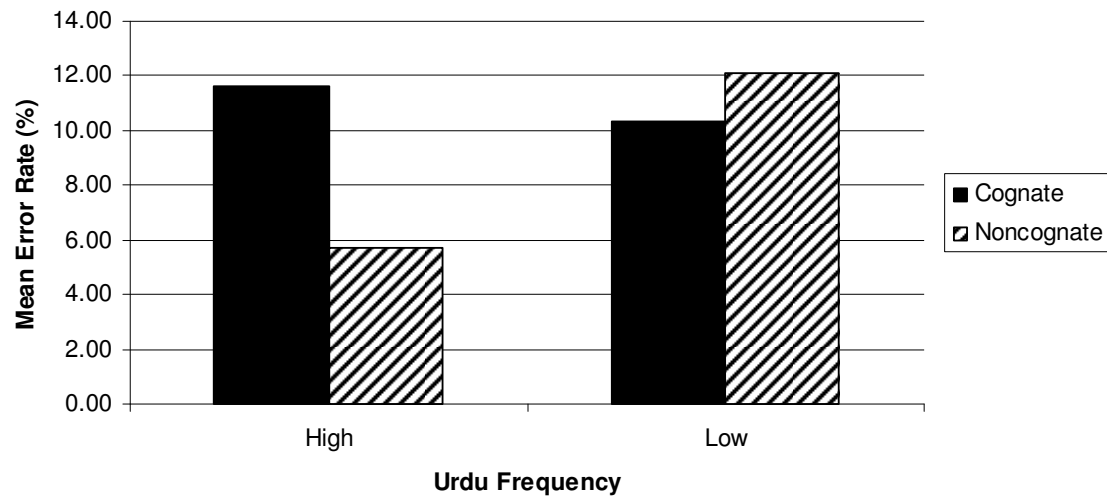
There was an interaction between Language and Urdu Frequency. Post hoc simple effects analysis show that when the target language was English, words with low-frequency Urdu translations had a lower error rate than words with high-frequency Urdu translations,  $F(1, 29) = 39.31, p < 0.05$ . However, when the target language was Urdu, high-frequency Urdu words had a lower error rate than low-frequency Urdu words,  $F(1, 29) = 76.86, p < 0.05$ . This interaction is shown in Figure 13.



*Figure 13.* Mean percentage Error Rate for words in English and Urdu as a function of Urdu Frequency.

There was an interaction between Status and Urdu Frequency. Post hoc simple effects analysis show that when the Urdu Frequency was high, more errors were made for cognate words than for noncognate words,  $F(1, 29) = 14.813$ ,  $p = 0.002$ . On the other hand, when Urdu Frequency was low, there was no difference in error rate between cognate and noncognate words,  $F(1, 29) = 1.34$ ,  $p = 0.26$ . This interaction is shown in Figure 14.





*Figure 14.* Mean percentage Error Rate for cognates and noncognates as a function of their Urdu Frequency.

There was also an interaction between English Frequency and Urdu Frequency. Post hoc simple effects analysis show that error rates for words which had a high-frequency in both English and Urdu were lower than error rates for words that had a high-frequency in English only,  $F(1, 29) = 63.42, p < 0.05$ . For words that were low-frequency in both English and Urdu the error rates were lower than for words that had a low-frequency in English only,  $F(1, 29) = 36.65, p < 0.05$ . This interaction is shown in Figure 15.

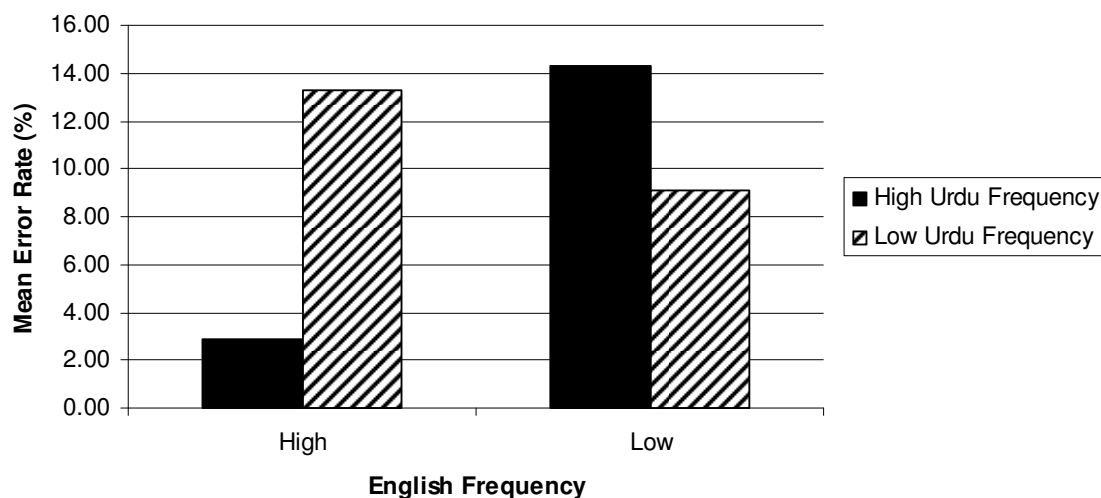


Figure 15. Interaction graph for English Frequency and Urdu Frequency.

The three-way interaction between Language, Status, and Urdu Frequency was only approaching significance. There were no other three-way interactions.

There was a four-way interaction between Language, Status, English Frequency, and Urdu Frequency.

**Planned comparisons.** A series of Paired Sample t-Tests were conducted.

*Frequency-balanced translation pairs.* There were no cognate effects in the frequency-balanced conditions when the target language was English and also when it was Urdu. This information is presented in Figures 16 and 17.

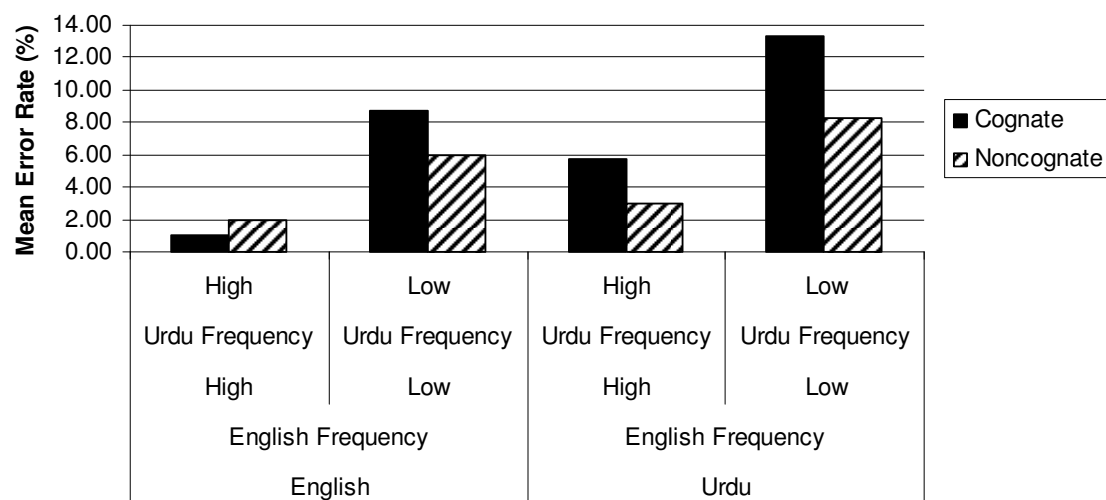


Figure 16. Mean percentage Error Rates for cognates and noncognates for the frequency balanced conditions for English and Urdu.

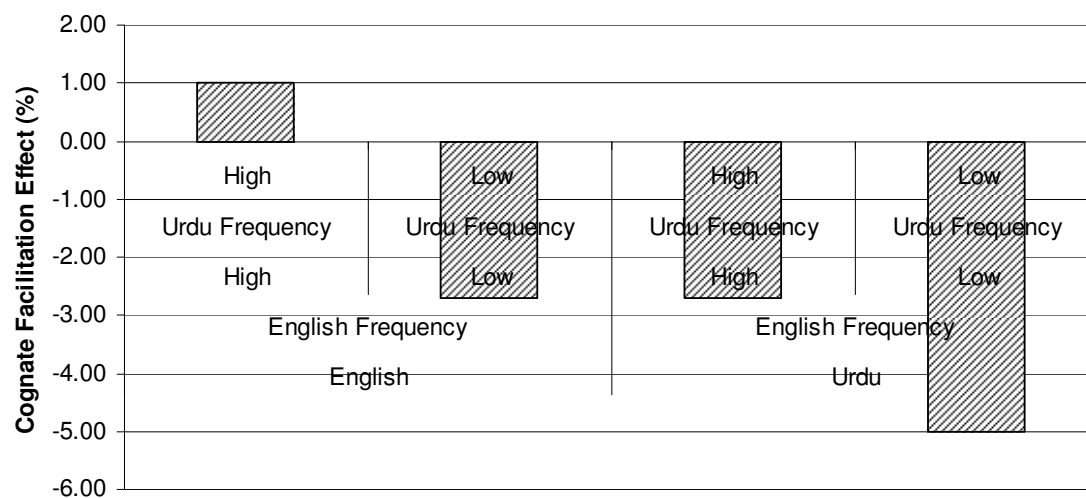
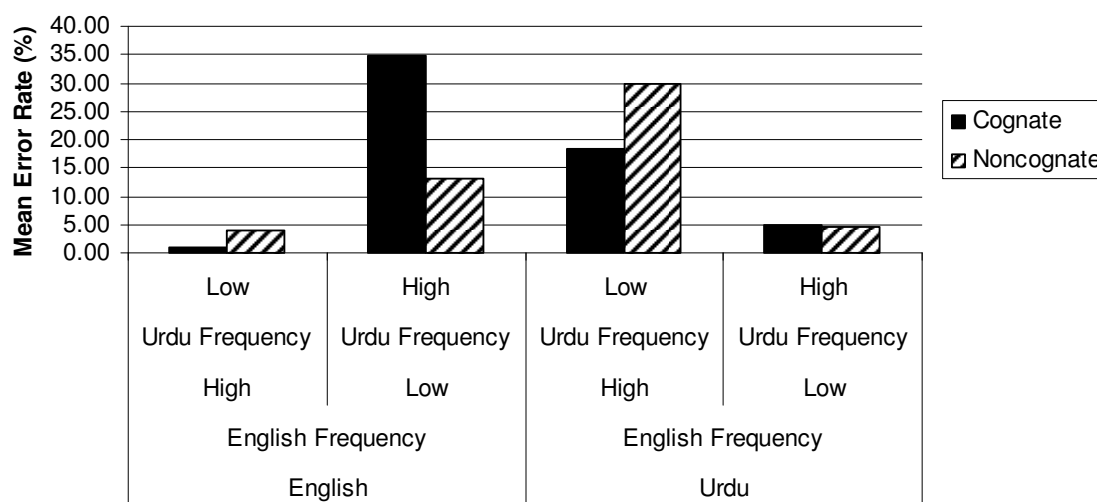


Figure 17. Cognate effect (% Error Rate) in English and Urdu for the frequency balanced conditions.

*Frequency-unbalanced translation pairs.* When the target language was English, there was a cognate effect for high-frequency English words with low-frequency Urdu translations, where cognates were responded to *more accurately* than noncognates. There was also a cognate effect for low-frequency English words with high-frequency Urdu translations such that cognates were responded to *less accurately* than noncognates. Further, when the target language was Urdu, there was a cognate effect for low-frequency Urdu words with high-frequency English translations such that cognates were responded to *more accurately* than noncognates. There were no cognate effects at any of the other frequency values. This information is presented in Figures 18 and 19.



*Figure 18.* Mean percentage Error Rates for cognates and noncognates for the frequency-unbalanced conditions for English and Urdu.

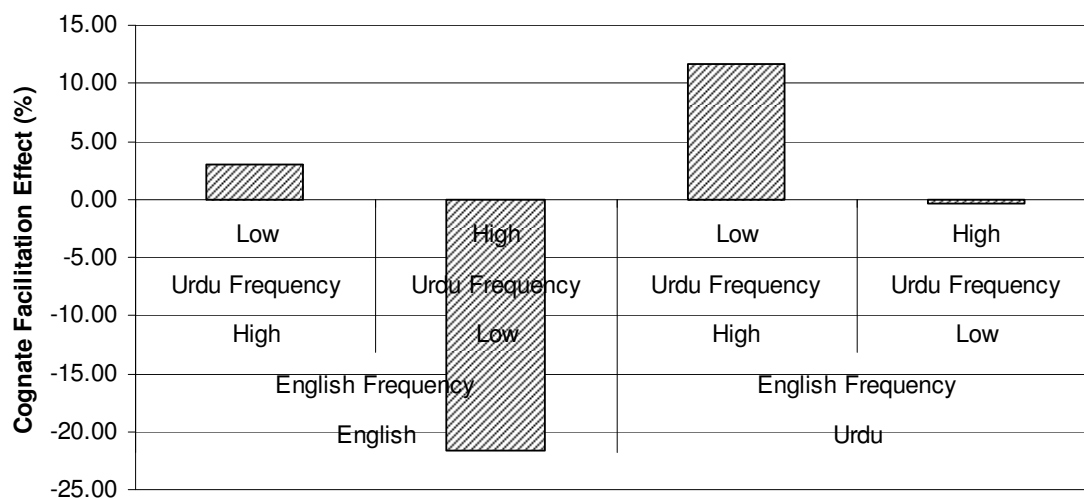


Figure 19. Cognate effect (% Error Rate) in English and Urdu for the frequency-unbalanced conditions.

## Discussion

The goal of this study was to determine if the cognate effect obtained for same script languages in the simple lexical decision task would also be obtained for a cross-script language pair when frequency-balanced and frequency-unbalanced translation pairs are used. While a main effect of status was not obtained, a series of planned comparisons revealed a cognate advantage for low-frequency English targets with low-frequency Urdu translations, and a reverse cognate effect for low- and high-frequency English targets with high-frequency Urdu translations. It is likely that the facilitation and inhibition obtained for words with different frequency properties cancel each other out resulting in a lack of overall cognate effect. The presence of both cognate facilitation and inhibition indicate that lexical access is nonselective for these cross-script languages. However, an

unusual aspect of the results was the absence of a cognate effect when the target language was Urdu.

It is interesting to note that although Urdu was the native language (L1) of the participants in this study, they recorded a higher proficiency in English on a reading task. In addition, self-reported fluency when averaged across the domains of speaking, comprehension, reading, and writing was also higher in English than in Urdu. Thus, English may be considered to be the dominant language (DL) for these participants while Urdu is the nondominant language (NL). Nevertheless, previous studies have shown that the processing of target words presented in the nondominant language is influenced by the highly activated dominant translation. Furthermore, in a previous pilot study I had shown that cross-language activation is obtained both when the target language is English and when it is Urdu (Khan, 2009). In that study a cognate effect was obtained for low-frequency Urdu target words whereas a reverse cognate effect was obtained for high-frequency Urdu target words. The absence of a cognate effect for Urdu in the current study indicates that this effect is unstable. This may be due to differences in the language proficiency of the subjects tested in the two experiments. The participants in these studies had a unique language background. While Urdu was their native language and spoken in everyday life, the language of instruction throughout their school years was English and Urdu was taught only as a language course. However, based on socioeconomic and cultural factors, the degree of daily exposure to Urdu, particularly in its written form, varies considerably amongst individuals. While all the participants in the current study showed higher English proficiency on a reading task, and self-reported

proficiency averaged across various modalities was also higher for English, individual differences in self-reported proficiency for the two languages were noted across the various modalities (i.e., speaking, comprehension, reading, and writing).

As reviewed in the introduction, previous research has shown that cross language activation depends on a number of factors including the level of second language proficiency. It has been argued that the cross-language activation of a weaker nontarget language is determined by the level of proficiency in the nondominant language such that higher proficiency increases the chances of cross-language activation and hence the emergence of a cognate effect when the target language is the dominant language (Van Hell & Dijkstra, 2002). In the current study it is clear that even when the nondominant language proficiency is high enough to bring about cross language activation when subjects are tested in their dominant language, the cognate facilitation effect may fail to emerge when subjects are tested in their nondominant language. In other words, the participants in this study were sufficiently proficient in Urdu to show cross-language activation when tested in English. However, even though English proficiency was high, they did not show any cross-language activation when tested in Urdu.

Indeed, an examination of the Urdu RT data revealed a large amount of variance in the RTs for Urdu, which may have obscured any potential cognate effect. This variability in RTs may be due to proficiency differences across participants and this possibility will be further discussed in the General Discussion.

In addition, an examination of RT latencies for Urdu target words revealed that these were considerably longer than RT latencies for English target words and it is

possible that the longer processing time for Urdu prevents the effect of translation word frequency from emerging. Urdu has a relatively complex Arabic script and previous research has shown that the greater perceptual load when processing Arabic results in longer processing times for reading and visual recognition in Arabic compared to English even when Arabic is the first language of the participants (Ibrahim, Eviatar, & Aharon-Peretz, 2002).

The results also indicate that both target and translation word frequencies play an important role in word processing. When both the English targets and their Urdu translations had low frequencies, a cognate effect emerged indicating cross-language facilitation. However, for low-frequency English target words with high-frequency translations a reverse cognate effect emerged indicating that the higher frequency translation may be interfering with the processing of the cognate word. This inhibition was also observed when high-frequency English target words with high-frequency Urdu translations were presented. When high-frequency English target words with low-frequency Urdu translations were presented, there was no facilitation or inhibition. In this case, the strong frequency effect for the high-frequency target words may have masked the weaker cognate effect.

In addition, although participants were explicitly told that a nonword is defined as one that has no meaning, and words that were high-frequency in Urdu and low-frequency in English (e.g., *chai*) were recognized correctly on the Urdu LDT, the error rate for these items was very high when the LDT was completed in English. Similarly, the error rate was very high for words that were high-frequency in English and low-frequency in Urdu



when the LDT was completed in Urdu. These findings indicate that there is a strong inhibitory effect for low-frequency target words with high-frequency translations.

A number of previous studies have found a cognate advantage for same-script words in the lexical decision task. More recently, Dijkstra, Miwa, Brummelhuis, Sappelli, and Baayen (2010a) tested Dutch-English bilinguals on a lexical decision task and found that when cognates with varying degree of form overlap were presented, RTs decreased as orthographic form overlap increased. However, when a language decision task was presented (i.e., when bilinguals were asked to make a decision about which language the presented word belongs to), the effect was reversed such that a cognate inhibition effect emerged, which increased in magnitude with increasing orthographic overlap. Dijkstra et al. (2010a) proposed that like interlingual homograph effects, cognate effects are also task dependant. In the current study however, a cognate inhibition effect was seen for cross-script cognates when the frequency of the nontarget translation equivalent was high even in the lexical decision task. One possible explanation is that cross-script cognates are processed differently than same-script cognates.

The BIA+ model has been used to explain cognate facilitation in the simple lexical decision task previously. According to this model, for cross-script languages like Urdu and English orthographically similar word candidates cannot be activated and it is assumed that support for language specific access will be obtained when cross-script languages are used in the LDT (Dijkstra & Van Heuven, 2002). However, this was not the case in the current study where clear activation and inhibition effects were seen for

the cross-script Urdu-English language pair. This suggests that phonological and semantic codes play an important role for such language pairs and provides evidence for language nonspecific access for a previously unstudied cross-script language pair.

## **CHAPTER III**

### **Experiment 2a**

#### **Within-Language Masked Priming in English (E-E) and Urdu (U-U) at 30 ms SOA**

The purpose of this experiment was to see if within-language masked priming can be obtained in English and Urdu at 30 ms SOA in order to ensure that participants in the following cross-language experiments would be able to benefit from a 30 ms prime. Additionally, as the priming effect has not been studied in Urdu previously, this experiment was undertaken to demonstrate the within-language priming effect in Urdu.

### **Method**

#### **Participants**

Seventeen Urdu-English bilinguals participated in this study (and also in another experiment with unpublished data). These participants were recruited from the same pool as Experiment 1.

#### **Materials and Apparatus**

Two experimental lists were created for this experiment (see Appendix A for the stimulus set). These were within-language priming lists in English and Urdu consisting of English primes followed by English targets (E-E) and Urdu primes followed by Urdu targets (U-U), respectively. English and Urdu target words in the E-E and U-U lists were matched on log frequency. Mean log frequency for English target words was 1.33

(SD=0.87) and for Urdu target words was 1.32 (SD=1.0). English and Urdu targets were also matched on word length (number of syllables). Mean word length for English target words was 1.75 (SD=0.59) and for Urdu target words it was 1.73 (SD=0.55).

A set of sixteen prime-target pairs was presented in the practice trial prior to the experimental stimuli. Half the target items were words and the other half were nonwords (see below for a description of nonwords).

**Within-language priming in English (E-E).** A within-language priming list was formed containing 40 English target words which were preceded by English primes. The target words in the list were matched with within-language unrelated primes on log frequency (all  $t$ s < 1.77 and all  $p$ s > 0.05) and syllable length (exact match) for all the conditions. Two versions of this list were created such that each target word was preceded by an identity prime and a control prime but each participant would see the target word only once. In the first list half the target words followed the presentation of an identity prime while the other half followed the presentation of an unrelated control prime. In the second list, these prime-target pairings were switched. Each participant was presented only one of these lists. The identity prime-target pairs and the unrelated control prime-target pairs consisted of two word frequency categories as follows: HFE-HFE and LFE-LFE. In this way, there were 4 conditions with 20 prime-target pairs in each condition. These conditions were: HFE-HFE word (high-frequency English words each preceded by an identity prime), HFE-HFE control (high-frequency English words each preceded by a high-frequency unrelated prime), LFE-LFE word (low-frequency English words each preceded by an identity prime), LFE-LFE control (low-frequency

English words each preceded by a low-frequency unrelated prime). The mean log frequency and word length in syllables for each of the conditions is presented in Table 6.

Forty nonwords were created by using words that matched the target words in length, bigram frequency, and orthographic neighbourhood. A letter was changed in each of these words to create orthographically and phonologically legal nonwords. The nonwords were preceded by unrelated English prime words.

**Within-language priming in Urdu (U-U).** The Urdu within-language priming list was formed in the same way as the English within-language priming list and consisted of 40 target words and the same four conditions. Target words in the list were matched with within-language unrelated primes on log frequency (all  $t$ s < - 0.66 and all  $p$ s > 0.05) and word length (exact match) in syllables for all the conditions. The mean log frequency and word length in syllables for each of the conditions is presented in Table 6.

Urdu nonwords were created by changing a letter in each word on another list of Urdu words to obtain orthographically and phonologically legal nonwords and were preceded by unrelated Urdu prime words.

Participants were tested using a Compaq Presario 1500 laptop. All stimuli were presented in the center of the screen in black against a white background. English primes were presented in lowercase letters and English targets were presented in uppercase letters. In order to mimic the switch from lowercase to uppercase in Urdu, two different fonts were used for the primes and targets. The participants' responses were recorded using the Direct RT software (Jarvis, 1999). Viewing distance was approximately 60 cm.

Table 6

*Mean log frequency (WF) and word length in number of syllables (WL) for the high-frequency English (HFE), low-frequency English (LFE), high-frequency Urdu (HFU), and low-frequency Urdu (LFU) conditions in Experiment 2a.*

List		Control Prime		Repetition Prime		Target	
		WL	WF	WL	WF	WL	WF
E-E	HFE-HFE	1.65	2.12	1.65	2.14	1.65	2.14
	LFE-LFE	1.85	0.53	1.85	0.52	1.85	0.52
U-U	HFU-HFU	1.65	2.24	1.65	2.23	1.65	2.23
	LFU-LFU	1.80	0.42	1.80	0.41	1.80	0.41

## Procedure

Participants were tested individually over two sessions: one with English target words and the other with Urdu target words. The order of presentation of the English and Urdu sessions was alternated between participants and testing was carried out with a gap of at least one week between the two experimental sessions. Instructions were given at the beginning of each session, which were in the same language as the target words for that session.

Participants were presented with a test of reading proficiency in the same language as the target words for that session. This test involved reading a passage in English or Urdu for one minute and was the same test used in Experiment 1. After this test, they were presented with a lexical decision task. In this task they were told to determine as quickly and accurately as possible, if the presented letter strings were real words or not. They pressed the “/” key if the presented string was a word and the “Z” key if it was not a word.

Each trial consisted of the presentation of a forward mask in the center of the screen for 500 ms. The forward mask comprised of a string of hash marks (e.g., #####). The length of this string was matched to the length of the prime word in order to successfully mask the prime. This was immediately followed by the presentation of the prime. Both English and Urdu primes were presented for 30ms. The prime was followed by the target word and remained on the screen until the participant made a response. The RT was measured from the onset of the target to when the subject pressed the response button.

After the experiment the participants were asked whether they were able to read and understand all of the stimulus material presented in the experiment. Also, they were asked whether they saw any prime words in the experiment.

A language background questionnaire was given to the participants after completion of the first session in order to assess their language proficiency. This was the same questionnaire used in Experiment 1.

### **Results**

Seventeen participants were tested in this experiment. However, four of the participants had missing values for the Reaction Time analysis in the U-U analysis. Consequently, their data was excluded from the final analysis. Thus, data from thirteen participants formed the basis of the analysis in this experiment. The results from the item analysis are presented in Appendix D.

#### **Language Fluency**

A series of paired sample t-tests indicated that reading proficiency for participants in Experiment 2a, as indicated by the number of words read within a specified period of time, was higher for English than for Urdu,  $t(12) = 4.739, p < 0.05$ . There was no difference in the number of errors made across the two languages on the reading task,  $t(12) = -0.714, p = 0.489$ . Self-reported language proficiency averaged across the domains of speaking, comprehension, reading, and writing was similar for English and Urdu,  $t(12) = 0.342, p = 0.738$ . See Table 7 for a summary of the results from the Language Questionnaire.

**Table 7**  
*Language History (Scale 1=Only Urdu, 2=Urdu > English, 3=Urdu=English, 4=English>Urdu; 5=Only English) and Self-assessed Urdu and English Proficiency Ratings (From 1=Nonfluent to 7=Native Fluency) for Experiment 2a.*

Proficiency Measure	Minimum	Maximum	Mean
<hr/>			
Proficiency (1-7)			
Urdu			
Speaking	5	7	6.62
Comprehension	2	7	5.69
Reading	2	7	5.39
Writing	3	7	5.27
English			
Speaking	3	7	6.00
Comprehension	4	7	5.85
Reading	4	7	6.08
Writing	4	7	5.69
Language Use (1-5)			
Speaking	1	5	3.00
Listening	1	5	3.62
Reading	3	5	4.00
Writing	2	5	4.15
Age of Acquisition (years old when began acquiring language)			
Urdu	0	2.50	1.31
English	0	7.00	3.23
<hr/>			

### **Within Language Priming in English (E-E)**

#### **Reaction Time**

**Subject Analysis.** After removing incorrect responses (3.85% of data), lower and upper absolute cut-off limits were set at 200ms and 2000ms respectively. This resulted in removal of 1.35% of the data. Reaction times greater than two standard deviations above



and below the mean for each participant for each condition were replaced with the appropriate cut-off value. This treatment was applied to 5.58% of the data. Mean lexical decision times were subsequently calculated for each of the conditions and this data is presented in Table 8.

***Analysis of Variance.*** An ANOVA was carried out, which consisted of the following variables: Group (List 1 versus List 2), Prime Type (identity versus unrelated), and Frequency (high versus low). The first variable was introduced by the counterbalancing procedure and extracted any variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach). The ANOVA statistics are presented in Table 9.

There was a main effect of Prime Type such that target words preceded by identity primes were responded to faster than those preceded by unrelated primes. There was also a main effect of Frequency such that high-frequency words had shorter response latencies than low-frequency words. There was no interaction between Prime Type and Frequency.

***Planned Comparisons.*** A series of paired sample t-tests (see Table 10 for the t-test statistics) revealed that there was a within language priming effect for high-frequency words but not for low-frequency words. See Figures 20 and 21.

Table 8  
*Mean Lexical Decision Times (in Milliseconds) and Percent Error Rates  
 Obtained for Within-Language Urdu (HFU-HFU, LFU-LFU) and English  
 (HFE-HFE, LFE-LFE) Priming Lists in Exp 2a.*

Condition	RT	% Error
HFU-HFU		
Repetition	839.40	3.08
Control	904.28	3.08
Priming	64.89	0
LFU-LFU		
Repetition	1196.56	19.23
Control	1139.39	21.54
Priming	-57.17	2.30
HFE-HFE		
Repetition	628.02	3.08
Control	678.62	1.54
Priming	50.60	-1.54
LFE-LFE		
Repetition	779.93	3.85
Control	813.50	6.92
Priming	33.56	3.08

Table 9

*The Results of 2 (Prime Type: Identity Vs. Unrelated) x 2 (Frequency: High Vs. Low) Repeated Measures Analysis of Variance for Experiment 2a.*

Language	Effect	Reaction Time			Error Rate		
		<i>df</i>	<i>F1</i> value	<i>p</i> value	<i>df</i>	<i>F2</i> value	<i>p</i> value
English-English							
	Main Effect						
	Prime Type	(1, 11)	8.47	<0.05	(1, 11)	0.10	=0.60
	Frequency	(1, 11)	16.25	<0.05	(1, 11)	1.99	=0.19
	Two-Way Interaction						
	Prime Type x Frequency	(1, 11)	0.03	=0.87	(1, 11)	0.89	=0.37
Urdu-Urdu							
	Main Effect						
	Prime Type	(1, 11)	0.41	=0.53	(1, 11)	0.30	=0.60
	Frequency	(1, 11)	74.91	<0.05	(1, 11)	50.42	<0.05
	Two-Way Interaction						
	Prime Type x Frequency	(1, 11)	7.97	=0.02	(1, 11)	0.46	=0.51

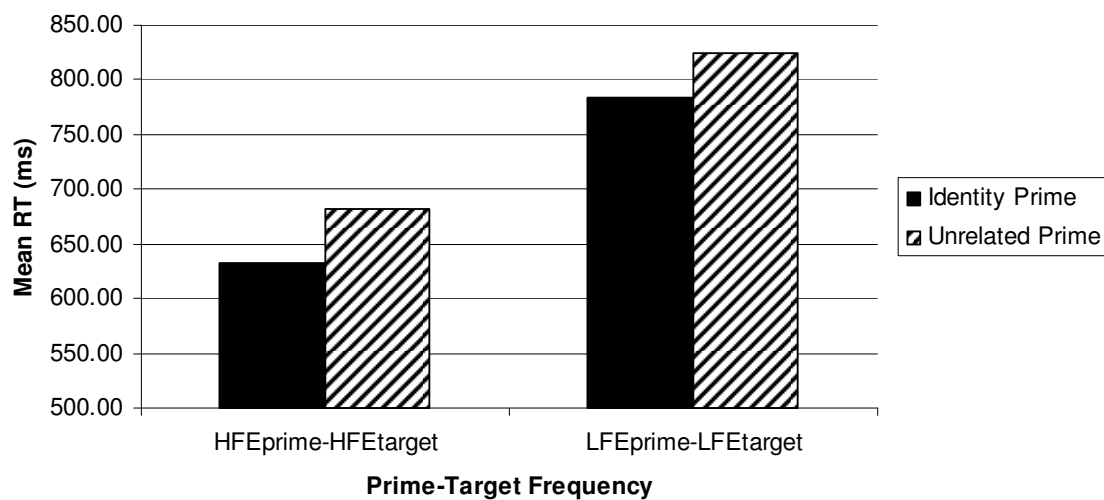
Note. *F1* = Reaction Time; *F2* = Error Rate

Table 10

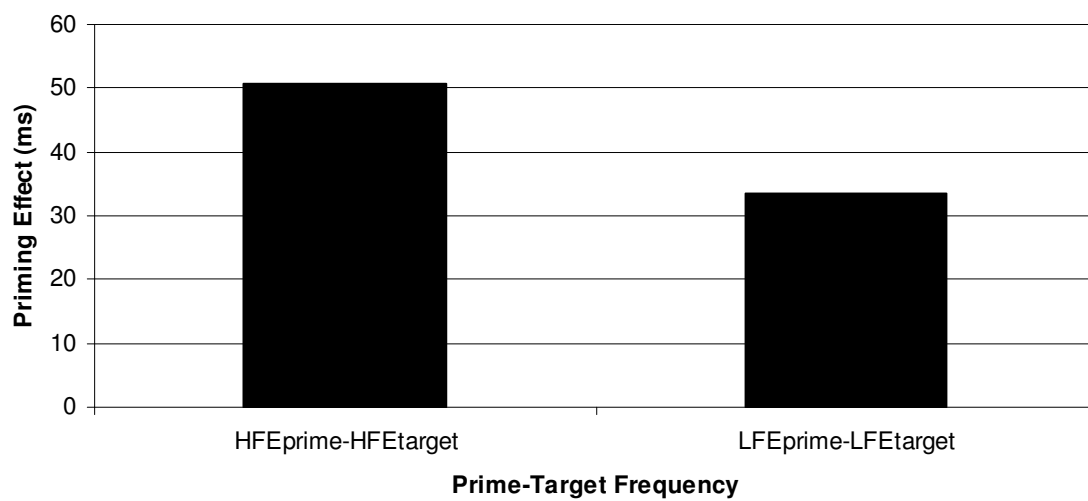
*The Results of the Paired Sample T-Tests Examining the Priming Effect for Experiment 2a.*

Language	Target Frequency	Prime Frequency	Subject Analysis				Error Analysis			
			<i>M</i> Diff. (ms)	<i>df</i>	<i>t</i> value	<i>p</i> value	<i>M</i> Diff.(%)	<i>df</i>	<i>t</i> value	<i>p</i> value
English-English	High	High	50.60	12	2.78	<0.05	-0.02	12	-1.00	=0.34
	Low	Low	33.56	12	0.98	=0.35	0.03	12	0.89	=0.39
Urdu-Urdu	High	High	64.89	12	2.14	=0.05	0.00	12	0.00	=1.00
	Low	Low	-57.17	12	-1.88	=0.09	0.02	12	0.43	=0.67

M Diff. = Mean Difference



*Figure 20.* Within-Language RT latencies (ms) for high-frequency English (HFE) and low-frequency English (LFE) prime-target pairs.



*Figure 21.* Within-Language Priming Effect (ms) for high-frequency English (HFE) and low-frequency English (LFE) prime-target pairs.

## **Error Rate**

**Subject Analysis.** An ANOVA was carried out, which consisted of the following variables: Group (List 1 versus List 2), Prime Type (identity versus unrelated), and Frequency (high versus low). The first variable was introduced by the counterbalancing procedure and extracted any variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach). The ANOVA statistics are reported in Table 9.

There was no main effect for Prime Type or Frequency. There was no interaction between Prime Type and Frequency.

**Planned Comparisons.** A series of paired sample t-tests revealed that there was no within language priming effect for both high-frequency and low-frequency words (see Table 10 for the t-test statistics).

## **Within Language Priming in Urdu (U-U)**

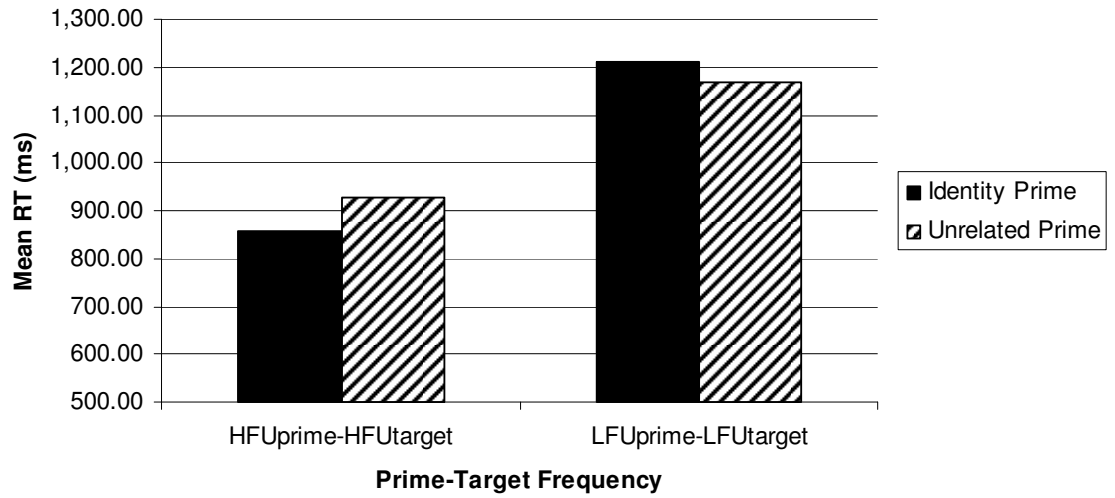
### **Reaction Time**

**Subject Analysis.** After removing incorrect responses (11.73% of data), lower and upper absolute cut-off limits were set at 200ms and 2000ms respectively. This resulted in removal of 8.65% of the data. Reaction times greater than two standard deviations above and below the mean for each participant for each condition were replaced with the appropriate cut-off value. This treatment was applied to 3.08% of the data. Mean lexical decision times were subsequently calculated for each of the conditions and this data is presented in Table 8.

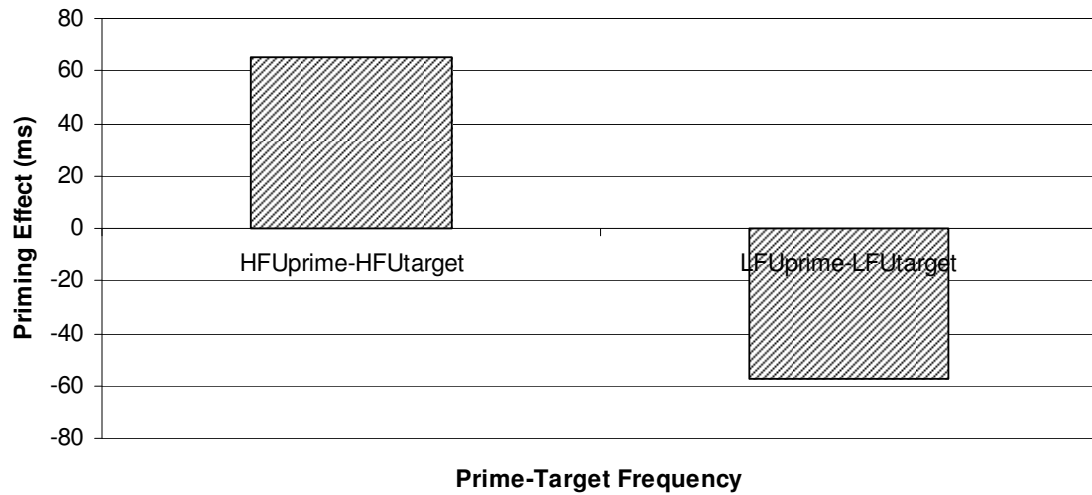
***Analysis of Variance.*** An ANOVA was carried out, which consisted of the following variables: Group (List 1 versus List 2), Prime Type (identity versus unrelated), and Frequency (high versus low). The first variable was introduced by the counterbalancing procedure and extracted any variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach). The ANOVA statistics are presented in Table 9.

There was no main effect of Prime Type. However, there was a main effect of Frequency, such that high-frequency words had shorter response latencies than low-frequency words.

There was an interaction between Prime Type and Frequency. Post hoc simple effects analysis revealed that high-frequency Urdu words were responded to faster when preceded by high-frequency identity primes compared to high-frequency unrelated primes,  $F(1,11) = 92.589$ ,  $p < 0.05$ . However, low-frequency Urdu words were responded to slower when preceded by low-frequency identity primes compared to low-frequency unrelated primes,  $F(1,11) = 31.119$ ,  $p < 0.05$ . See Figure 22.



*Figure 22.* Within-Language RT latencies (ms) for high-frequency Urdu (HFU) and low-frequency Urdu (LFU) prime-target pairs.



*Figure 23.* Within-Language Priming Effect (ms) for high-frequency Urdu (HFU) and low-frequency Urdu (LFU) prime-target pairs.



***Planned Comparisons.*** A series of paired sample t-tests revealed that the within language priming effect was approaching significance for high-frequency words and there was no priming effect for low-frequency words. See Table 10 for the t-test statistics and Figures 23.

### **Error Rate**

***Subject Analysis.*** An ANOVA was carried out, which consisted of the following variables: Group (List 1 versus List 2), Prime Type (identity versus unrelated), and Frequency (high versus low). The first variable was introduced by the counterbalancing procedure and extracted any variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach). The ANOVA statistics are presented in Table 9.

There was no main effect of Prime Type. However, there was a main effect of Frequency. There was no interaction between Prime Type and Frequency.

***Planned comparisons.*** A series of paired sample t-tests revealed that there was no within language priming effect for high-frequency and low-frequency words. The t-test statistics are presented in Table 10.

### **Discussion**

The purpose of the within language U-U condition was twofold. First, as masked priming in Urdu has not been demonstrated previously, it is important to replicate the masked priming effect within Urdu before using Urdu primes in cross-language priming. Second, it is important to confirm that these bilinguals can process and benefit from 30 ms masked Urdu primes in the NL-NL within language condition before interpreting the

results from the NL-DL cross-language priming condition. The results indicate that these bilinguals were unable to process and benefit from a 30 ms Urdu prime. The failure to obtain within language priming in Urdu means that no conclusions can be drawn from the cross-language Urdu-English translation priming condition. In the following experiment (Experiment 2b), the Urdu prime duration was increased to 50 ms in order to increase the likelihood of obtaining a within language priming effect for Urdu.

The purpose of the within language E-E condition was to confirm that these bilinguals can process and benefit from 30 ms masked English primes. The results from the within language E-E condition indicate that these bilinguals were able to process and benefit from a 30 ms English prime. Therefore, in the following experiment (Experiment 2b), English primes were presented for 30 ms in the within-language and cross-language conditions.

## **CHAPTER IV**

### **Experiment 2b**

#### **Masked Priming from Urdu to English (NL-DL) at 50 ms SOA and from English to Urdu (DL-NL) at 30 ms SOA Using Frequency-Balanced and Frequency-**

#### **Unbalanced Cognates and Noncognates**

#### **Method**

##### **Participants**

Twenty-nine Urdu-English bilinguals participated in this study. These participants were recruited from the same pool as Experiment 1.

## Materials and Apparatus

Four different experimental lists were created for this experiment. Two of these lists were within-language priming lists in English and Urdu consisting of English primes followed by English targets (E-E) and Urdu primes followed by Urdu targets (U-U), respectively. These were the same lists that were used in Experiment 2a.

The other two lists were cross-language priming lists such that in one of the lists English targets were preceded by Urdu primes whereas in the other list Urdu targets were preceded by English primes (see Appendix A for the stimulus set). English and Urdu target words were matched on log frequency,  $t(79) = -0.01, p = 0.99$ . Mean log frequency for English target words was 1.23 (SD=0.97) and for Urdu target words was 1.23 (SD=0.93). Word length (number of syllables) for English target words was 1.58 (SD=0.50) and for Urdu target words it was 1.71 (SD=0.46).

A set of sixteen prime-target pairs was presented in the practice trial prior to the experimental stimuli. Half the target items were words and the other half were nonwords (see below for description of nonwords).

**Cross-language priming from Urdu to English (U-E).** The word list consisted of 80 target words in English of which half were cognates and the other half were noncognates. The cognate and noncognate target words were matched on frequency and word length (number of syllables) as much as possible. The average log frequency of the targets in the list was 1.19 (SD=1.07) for cognates and 1.27 (SD=0.88) for noncognates and was not significantly different,  $t(39) = -0.98, p = 0.33$ . The word length of the cognate targets was 1.7 (SD=0.46) and for the noncognate targets was 1.45 (SD=0.50).

and this difference was significant,  $t(39) = 2.69, p < 0.05$ . As the higher syllable length would decrease the chances of finding a cognate effect, the presence of a cognate effect would be indicative of a strong effect. Two versions of this list were created such that each target word was preceded by a translation equivalent and a control prime but each participant would see the target word only once. In the first list, half the target words followed the presentation of a translation prime while the other half followed the presentation of an unrelated control prime. In the second list, these prime-target pairings were switched. Each participant was presented only one of these lists. Target words were matched with cross-language translation primes on log frequency for all the frequency-balanced conditions (all  $ts < -0.04$  and all  $ps > 0.05$ ) except for the LFU-LFE noncognate (low-frequency English target preceded by low-frequency Urdu noncognate prime) condition,  $t(9) = 2.48, p < 0.05$ , where Urdu primes had a lower frequency than English targets. Nevertheless, the word frequency for both Urdu primes and English targets was less than 11 per million.

Targets were also matched with their cross-language translation primes on word length for all the conditions (all  $ts < -0.43$  and all  $ps > 0.05$ ). Translation primes were matched with the unrelated primes on log frequency and word length for each of the conditions. Further, the translation prime-target pairs and the unrelated control prime-target pairs consisted of four word frequency categories as follows: HFU-HFE, HFU-LFE, LFU-HFE, and LFU-LFE. In this way, there were 16 conditions with 10 prime-target pairs in each condition (See Table 11 for a description of the experimental set up). These conditions were: HFU-HFE cognate (high-frequency English target preceded by

high-frequency Urdu cognate prime), HFU-HFE control (high-frequency English target preceded by high-frequency Urdu unrelated prime), HFU-LFE cognate (low-frequency English target preceded by high-frequency Urdu cognate prime), HFU-LFE control (low-frequency English target preceded by high-frequency Urdu unrelated prime), LFU-HFE cognate (high-frequency English target preceded by low-frequency Urdu cognate prime), LFU-HFE control (high-frequency English target preceded by low-frequency Urdu unrelated prime), LFU-LFE cognate (low-frequency English target preceded by low-frequency Urdu cognate prime), LFU-LFE control (low-frequency English target preceded by low-frequency Urdu unrelated prime), HFU-HFE noncognate (high-frequency English target preceded by high-frequency Urdu noncognate prime), HFU-HFE control (high-frequency English target preceded by high-frequency Urdu unrelated prime), HFU-LFE noncognate (low-frequency English target preceded by high-frequency Urdu noncognate prime), HFU-LFE control (low-frequency English preceded by high-frequency Urdu unrelated prime), LFU-HFE noncognate (high-frequency English target preceded by low-frequency Urdu noncognate prime), LFU-HFE control (high-frequency English target preceded by low-frequency Urdu unrelated prime), LFU-LFE noncognate (low-frequency English target preceded by low-frequency Urdu noncognate prime), LFU-LFE control (low-frequency English target preceded by low-frequency Urdu unrelated prime). The mean log frequency and word length in syllables for each of the conditions is presented in Table 12.

Eighty nonwords were formed by using words that matched the target words in length, bigram frequency, and orthographic neighbourhood. A letter was changed in each

of these words to create orthographically and phonologically legal nonwords. Following the procedure used by Gollan et al. (1997), the nonwords were preceded by Urdu words that were translation equivalents of the words that had been used to create the nonword.

**Cross-language priming from English to Urdu (E-U).** The same word list was used as for cross language priming from Urdu to English with the prime and target switched such that the target words were in Urdu and were preceded by their cognate or noncognate English translations. The average log frequency of the targets in the list was 1.34 (SD=0.77) for cognates and 1.12 (SD=1.06) for noncognates. The cognate and noncognate targets were matched on word frequency,  $t(39) = 0.56, p > 0.05$ . The word length of the cognate targets was 1.73 (SD=0.45) and for the noncognate targets was 1.70 (SD=0.46) and was not significantly different,  $t(39) = 0.27, p > 0.05$ . Target words were matched with cross-language translation primes on frequency for all the frequency-balanced conditions except for LFE-LFU noncognate condition as described above. The frequency of these words was less than that of their English language translation primes. Targets were matched with their cross-language translation primes on word length. For the control condition, unrelated primes were used that were matched in log frequency and word length to the translation primes. See Table 11 for a description of the experimental set up. The mean log frequency and word length in syllables for each of the conditions is presented in Table 12.

Urdu nonwords were created by changing a letter in each word on another list of Urdu words to obtain orthographically and phonologically legal nonwords. These were

preceded by English words that were translation equivalents of the words that had been used to create the nonword.

Table 11

*A Description of the Design for the Cross-Language Priming Condition in Experiment 2*

Condition	Control Prime	Translation Prime	Target
Cognate			
U-E	HFU unrelated	HFU cognate	HFE cognate
	HFU unrelated	HFU cognate	LFE cognate
	LFU unrelated	LFU cognate	HFE cognate
	LFU unrelated	LFU cognate	LFE cognate
E-U	HFE unrelated	HFE cognate	HFU cognate
	HFE unrelated	HFE cognate	LFU cognate
	LFE unrelated	LFE cognate	HFU cognate
	LFE unrelated	LFE cognate	LFU cognate
Noncognate			
U-E	HFU unrelated	HFU noncognate	HFE noncognate
	HFU unrelated	HFU noncognate	LFE noncognate
	LFU unrelated	LFU noncognate	HFE noncognate
	LFU unrelated	LFU noncognate	LFE noncognate
E-U	HFE unrelated	HFE noncognate	HFU noncognate
	HFE unrelated	HFE noncognate	LFU noncognate
	LFE unrelated	LFE noncognate	HFU noncognate
	LFE unrelated	LFE noncognate	LFU noncognate

Table 12

*Mean Log Frequency (WF) and Word Length in Number of Syllables (WL) for the English-Urdu (E-U) and Urdu-English (U-E) Cross Language Priming Conditions in Experiment 2b.*

List	Word Type											
	Cognates						Noncognates					
	Control Prime		Repetition/Translation Prime		Target		Control Prime		Repetition/Translation Prime		Target	
	WL	WF	WL	WF	WL	WF	WL	WF	WL	WF	WL	WF
E-U												
HFE-HFU	1.60	2.09	1.60	2.09	1.60	2.09	1.30	2.07	1.30	2.05	1.30	2.13
HFE-LFU	1.50	2.12	1.50	2.17	1.60	0.74	1.20	2.02	1.20	2.05	1.80	0.31
LFE-HFU	1.70	0.30	1.70	0.13	1.70	2.01	1.70	0.47	1.70	0.39	1.80	1.93
LFE-LFU	2.00	0.41	2.00	0.37	2.00	0.53	1.60	0.58	1.60	0.60	1.90	0.13
U-E												
HFU-HFE	1.60	2.10	1.60	2.09	1.60	2.09	1.30	2.13	1.30	2.13	1.30	2.05
HFU-LFE	1.70	2.01	1.70	2.01	1.70	0.13	1.80	1.93	1.80	1.93	1.70	0.39
LFU-HFE	1.60	0.74	1.60	0.74	1.50	2.17	1.80	0.51	1.80	0.31	1.20	2.05
LFU-LFE	2.00	0.53	2.00	0.53	2.00	0.37	1.90	0.36	1.90	0.13	1.60	0.60

*Note. HFE = High-Frequency English, LFE = Low-Frequency English, HFU = High-Frequency Urdu, and LFU = Low-Frequency Urdu.*



Participants were tested using a Compaq Presario 1500 laptop. All stimuli were presented in the center of the screen in black against a white background. English primes were presented in lowercase letters and English targets were presented in uppercase letters. In order to mimic the switch from lowercase to uppercase in Urdu, two different fonts were used for the primes and targets. The participants' responses were recorded using the Direct RT software (Jarvis, 1999). Viewing distance was approximately 60 cm.

### **Procedure**

Participants were tested individually over two sessions: one with English target words and the other with Urdu target words. The order of presentation of the English and Urdu sessions was alternated between participants and testing was carried out with a gap of at least one week between the two experimental sessions. Instructions were given at the beginning of each session, which were in the same language as the target words for that session.

Participants were presented with a test of reading proficiency in the same language as the target words for that session. This test was similar to that in Experiment 1. After this test, they were presented with a lexical decision task. In this task they were told to determine as quickly and accurately as possible, if the presented letter strings were real words or not. They pressed the “/” key if the presented string was a word and the “Z” key if it was not a word.

Each trial consisted of the presentation of a forward mask in the center of the screen for 500 ms. The forward mask comprised of a string of hash marks (e.g., #####). The length of this string was matched to the length of the prime word in order to successfully mask the prime. This was immediately followed by the presentation

of the prime. English primes were presented for 30ms while Urdu primes were presented for 50 minutes. The prime was followed by the target word and remained on the screen until the participant made a response. The RT was measured from the onset of the target to when the subject pressed the response button.

After the experiment the participants were asked whether they were able to read and understand all of the stimulus material presented in the experiment. Also, they were asked whether they saw any prime words in the experiment.

A language background questionnaire was given to the participants after completion of the first session in order to assess their language proficiency.

### **Results**

Twenty-nine participants were tested in this experiment. One of the participants reported that her first language was Sindhi (one of the provincial languages in Pakistan) after completing the experiment. The data from this participant was excluded from the analysis. Another participant failed to comply with the instructions for the lexical decision task such that the integrity of her data may have been compromised. The data from this participant was also excluded from the analysis. Four of the participants made more than 20% errors (averaged across the Within Language and Cross Language conditions) and were also removed from the analysis. Data from twenty-three participants was analyzed originally. However, four of the participants had missing values for the Reaction Time analysis in the U-U analysis. Consequently, their data was excluded from the U-U and U-E analysis. Thus, data from nineteen participants formed the basis of the analysis in this experiment. The results from the item analysis are presented in Appendix D.

### **Language Fluency**

A series of paired sample t-tests indicated that reading proficiency for participants in Experiment 2b, as indicated by the number of words read within a specified period of time, was higher for English than for Urdu,  $t(18) = 9.822, p < 0.05$ . There was no difference in the number of errors made across the two languages on the reading task,  $t(18) = -0.901, p = 0.379$ . Self-reported language proficiency averaged across the domains of speaking, comprehension, reading, and writing was also higher for English than for Urdu,  $t(20) = 2.515, p < 0.05$ . See Table 13 for a summary of the results from the Language Questionnaire.

Table 13

*Language History (Scale 1=Only Urdu, 2=Urdu > English, 3=Urdu=English, 4=English>Urdu; 5=Only English) and Self-assessed Urdu and English Proficiency Ratings (From 1=Nonfluent to 7=Native Fluency) for Experiment 2b.*

Proficiency Measure	Minimum	Maximum	Mean
Proficiency (1-7)			
Urdu			
Speaking	4	7	5.63
Comprehension	4	7	5.84
Reading	1	7	4.47
Writing	1	7	4.26
English			
Speaking	3	7	5.53
Comprehension	3	7	5.68
Reading	2	7	5.95
Writing	2	7	5.68
Language Use (1-5)			
Speaking	2	5	3.05
Listening	2	5	3.21
Reading	2	5	3.94
Writing	2	5	4.21
Age of Acquisition (years old when began acquiring language)			
Urdu	0	4	1.66
English	0	6	3.92

### Within Language Priming in English (E-E)

#### Data Treatment

After removing incorrect responses (4.87% of data), lower and upper absolute cut-off limits were set at 200ms and 2000ms respectively. This resulted in removal of 0.53% of the data. Reaction times greater than two standard deviations above and below the mean for each participant for each condition were replaced with the appropriate cut-

off value. This treatment was applied to 5.13% of the data. Mean lexical decision times were subsequently calculated for each of the conditions and this data is presented in

Table 14.

Table 14

*Mean Lexical Decision Times (in Milliseconds) and Percentage Error Rates Obtained for Within-Language Urdu (HFU-HFU, LFU-LFU) and English (HFE-HFE, LFE-LFE) Priming Lists in Exp 2b.*

Condition	RT	% Error
HFU-HFU		
Repetition	704.56	5.26
Control	760.07	5.26
Priming	55.51	0
LFU-LFU		
Repetition	939.49	25.79
Control	1013.77	26.32
Priming	74.27	0.53
HFE-HFE		
Repetition	590.19	1.58
Control	612.79	3.68
Priming	22.60	2.11
LFE-LFE		
Repetition	708.10	7.37
Control	716.49	6.84
Priming	8.39	-0.53

## Reaction Time

**Subject Analysis.** An ANOVA was carried out, which consisted of the following variables: Group (List 1 versus List 2), Prime Type (identity versus unrelated), and Frequency (high versus low). The first variable was introduced by the counterbalancing procedure and extracted any variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach). The ANOVA statistics are presented in Table 15.

There was no main effect of Prime Type. However, there was a main effect of Frequency such that high-frequency words had shorter response latencies than low-frequency words. There was no interaction between Prime Type and Frequency.

A series of paired sample t-tests revealed that there was no within language priming effect for high-frequency or low-frequency words. The t-test statistics are presented in Table 16.

### **Error Rate**

**Subject Analysis.** An ANOVA was carried out, which consisted of the following variables: Group (List 1 versus List 2), Prime Type (identity versus unrelated), and Frequency (high versus low). The first variable was introduced by the counterbalancing procedure and extracted any variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach). The ANOVA statistics are presented in Table 15.

There was no main effect of Prime Type. However, there was a main effect of Frequency such that high-frequency words were recognized more accurately than low-frequency words. There was no interaction between Prime Type and Frequency.

A series of paired sample t-tests revealed that there was no within language priming effect for high-frequency or low-frequency words. The t-test statistics are presented in Table 16.

Table 15

*The Results of 2 (Prime Type: Identity Vs. Unrelated) x 2 (Frequency: High Vs. Low) Repeated Measures Analysis of Variance for Experiment 2b.*

Language	Effect	Reaction Time			Error Rate		
		<i>df</i>	<i>F1</i> value	<i>p</i> value	<i>df</i>	<i>F2</i> value	<i>p</i> value
English-English	Main Effect						
	Prime Type	(1, 17)	1.14	=0.30	(1, 17)	0.13	=0.72
	Frequency	(1, 17)	61.88	<0.05	(1, 17)	4.84	<0.05
	Two-Way Interaction						
	Prime Type x Frequency	(1, 17)	0.28	=0.60	(1, 17)	1.14	=0.30
Urdu-Urdu	Main Effect						
	Prime Type	(1, 17)	12.70	<0.05	(1, 17)	0.02	=0.88
	Frequency	(1, 17)	108.07	<0.05	(1, 17)	36.86	<0.05
	Two-Way Interaction						
	Prime Type x Frequency	(1, 17)	0.58	=0.46	(1, 17)	0.002	=0.97

Note. *F1* = Reaction Time; *F2* = Error Rate

Table 16

*The Results of the Paired Sample T-Tests Examining the Priming Effect for Experiment 2b.*

Language	Target Frequency	Prime Frequency	Reaction Time				Error Analysis			
			<i>M</i> Diff. (ms)	<i>df</i>	<i>t</i> value	<i>p</i> value	<i>M</i> Diff.(%)	<i>df</i>	<i>t</i> value	<i>p</i> value
English-English	High	High	22.60	18	1.63	=0.12	2.11	18	1.17	=0.26
	Low	Low	8.39	18	0.48	=0.64	0.53	18	-0.24	=0.82
Urdu-Urdu	High	High	55.51	18	2.76	<0.05	0.00	18	0.00	=1.00
	Low	Low	74.28	18	2.52	<0.05	0.53	18	0.11	=0.91

M Diff. = Mean Difference



## Discussion

The results indicate that these bilinguals were *unable* to process and benefit from a 30 ms English prime. The failure to obtain within language priming in English means that no conclusions can be drawn from the cross-language English-Urdu translation priming condition. Therefore, the results from the cross-language English-Urdu translation priming experiment will not be presented here.

### Within Language Priming in Urdu (U-U)

#### Data Treatment

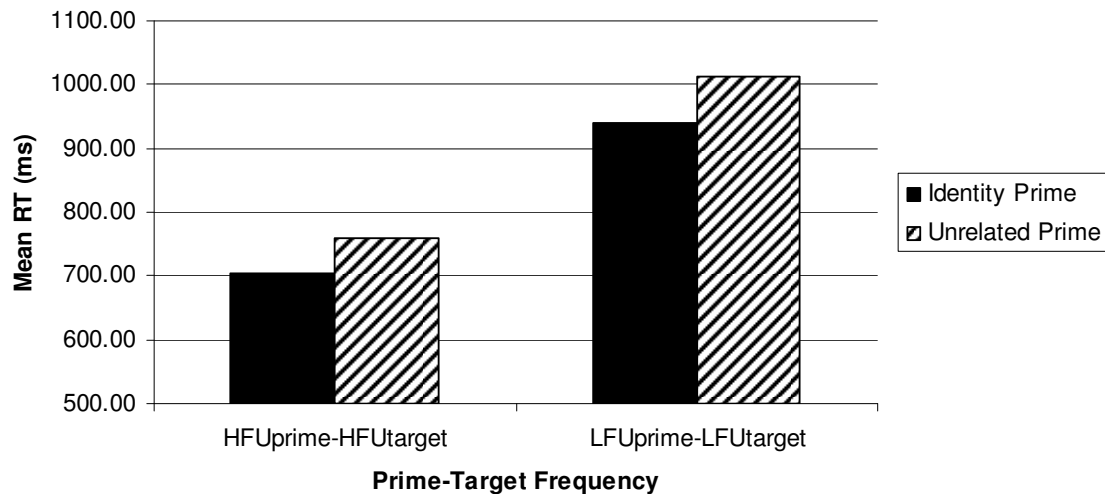
After removing incorrect responses (15.66% of data), lower and upper absolute cut-off limits were set at 200ms and 2000ms respectively. This resulted in removal of 2.5% of the data. Reaction times greater than two standard deviations above and below the mean for each condition for each participant were replaced with the appropriate cut-off value. This treatment was applied to 3.82% of the data. Mean lexical decision times were subsequently calculated for each of the conditions and this data is presented in Table 14.

#### Reaction Time

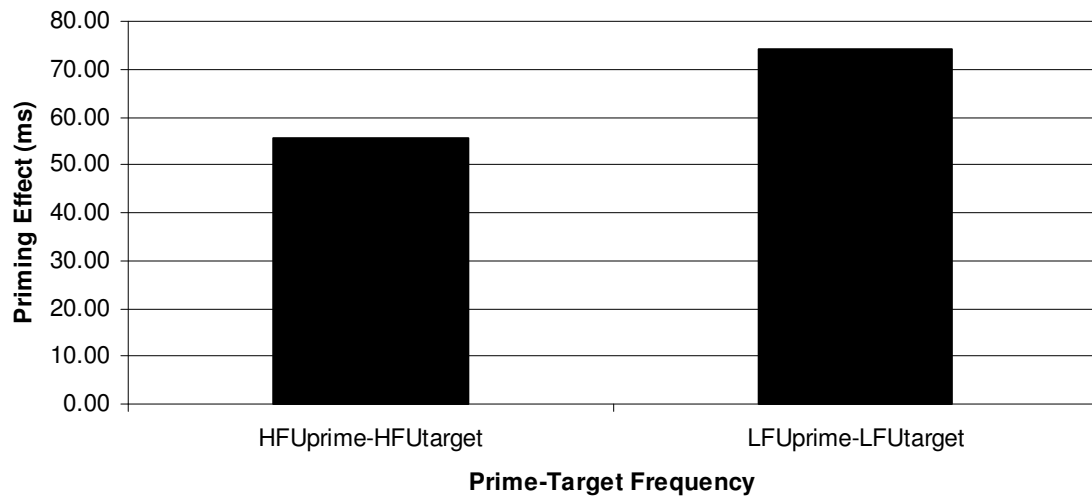
**Subject Analysis.** An ANOVA was carried out, which consisted of the following variables: Group (List 1 versus List 2), Prime Type (identity versus unrelated), and Frequency (high versus low). The first variable was introduced by the counterbalancing procedure and extracted any variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach). The ANOVA statistics are presented in Table 15.

There was a main effect of Prime Type such that repetition priming resulted in shorter response latencies compared to priming with unrelated words. This indicated that masked priming is obtained in Urdu and that the bilingual participants in the current experiment were able to process and benefit from a 50 ms Urdu prime. There was also a main effect of Frequency such that high-frequency words had shorter response latencies compared to low-frequency words. There was no interaction between Prime Type and Frequency.

A series of paired sample t-tests revealed that there was a within language priming effect for both high-frequency and low-frequency words (See Figures 24 and 25). The t-test statistics are presented in Table 16.



*Figure 24.* Within-Language RT latencies (ms) for high-frequency Urdu (HFU) and low-frequency Urdu (LFU) prime-target pairs.



*Figure 25.* Within-Language Priming Effect (ms) for high-frequency Urdu (HFU) and low-frequency Urdu (LFU) prime-target pairs.

### Error Rate

**Subject Analysis.** An ANOVA was carried out, which consisted of the following variables: Group (List 1 versus List 2), Prime Type (identity versus unrelated), and Frequency (high versus low). The first variable was introduced by the counterbalancing procedure and extracted any variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach). The ANOVA statistics are presented in Table 15.

There was no main effect of Prime Type. However, there was a main effect of Frequency such that high-frequency words were recognized more accurately than low-frequency words. There was no interaction between Prime Type and Frequency.

A series of paired sample t-tests revealed that there was no within language priming effect for high-frequency or low-frequency words. The t-test statistics are presented in Table 16.

## **Discussion**

It is important to show that participants benefit from a 50 ms nondominant language prime in the ND-ND within language condition before attempting to interpret the results from ND-DL cross language priming. The results confirm that participants can process and benefit from a 50 ms masked Urdu prime.

### **Cross Language Priming from Urdu to English (U-E)**

#### **Data Treatment**

After removing incorrect responses (6.97% of data), lower and upper absolute cut-off limits were set at 200ms and 2000ms respectively. This resulted in removal of 0.86% of the data. There were no reaction times greater than two standard deviations above and below the mean for that condition across all participants. Therefore, none of the data points were replaced with a cut-off value. Mean lexical decision times were calculated for each of the conditions and this data is presented in Table 17.

Table 17

*Mean Lexical Decision Times (in Milliseconds) and Percent Error Rates  
Obtained for Cross-Language Urdu-English (HFU-HFE, LFU-LFE,  
HFU-LFE, LFU-HFE) Priming Lists in Exp 2b.*

Condition	Target			
	Cognate		Noncognate	
	Mean	% Error	Mean	% Error
HFU-HFE				
Translation	616.46	0	569.59	2.10
Control	584.95	0	580.59	0
Priming	-31.60	0	11.00	-2.10
LFU-LFE				
Translation	656.93	3.16	716.18	11.58
Control	651.44	2.11	668.95	11.58
Priming	-5.49	-1.05	-47.22	0
LFU-HFE				
Translation	574.42	4.20	590.31	3.16
Control	585.07	2.10	656.84	3.16
Priming	10.66	-2.10	66.53	0
HFU-LFE				
Translation	715.73	20.00	665.29	8.42
Control	711.14	25.26	690.52	14.74
Priming	-4.59	5.26	25.22	6.30

## Reaction Time

**Subject Analysis.** An ANOVA was carried out, which consisted of the following variables: Group (List 1 versus List 2), Status (cognate versus noncognate), Prime Type (identity versus unrelated), Target Frequency (high versus low), and Prime Frequency (high versus low). The first variable was introduced by the counterbalancing procedure and extracted any variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach). The ANOVA statistics are presented in Table 18. However, of

Table 18

*The Results of 2 (Status: Cognate Vs. Noncognates) x 2 (Prime Type: Translation Vs. Unrelated) x 2 (English Frequency: High Vs. Low) x 2 (Urdu Frequency: High Vs. Low) Repeated Measures Analysis of Variance for Experiment 2b.*

Language	Effect	Reaction Time			Error Rate		
		<i>df</i>	<i>F1</i> value	<i>p</i> value	<i>df</i>	<i>F2</i> value	<i>p</i> value
Urdu-English	Main Effect						
	Status	(1, 17)	0.19	=0.67	(1, 17)	0.10	=0.76
	Prime Type	(1, 17)	0.12	=0.74	(1, 17)	0.02	=0.89
	Target Frequency	(1, 17)	35.87	<0.05	(1, 17)	83.54	<0.05
	Prime Frequency	(1, 17)	0.12	=0.73	(1, 17)	13.40	<0.05
	Two-Way Interaction						
	Status x Prime Type	(1, 17)	0.54	=0.47	(1, 17)	1.10	=0.31
	Status x Target Frequency	(1, 17)	0.30	=0.59	(1, 17)	0.94	=0.35
	Status x Prime Frequency	(1, 17)	17.88	<0.05	(1, 17)	13.26	<0.05
	Prime Type x Target Frequency	(1, 17)	0.69	=0.42	(1, 17)	0.52	=0.48
	Prime Type x Prime Frequency	(1, 17)	0.65	=0.43	(1, 17)	0.03	=0.87
	Target Frequency x Prime Frequency	(1, 17)	3.60	=0.08	(1, 17)	30.16	<0.05
	Three-Way Interaction						
	Status x Prime Type x Target Frequency	(1, 17)	1.90	=0.19	(1, 17)	0.40	=0.54
	Status x Prime Type x Prime Frequency	(1, 17)	0.34	=0.57	(1, 17)	0.21	=0.66
	Status x Target Frequency x Prime Frequency	(1, 17)	0.002	=0.97	(1, 17)	21.63	<0.05
	Prime Type x Target Frequency x Prime Frequency	(1, 17)	3.49	=0.08	(1, 17)	0.25	=0.62
	Four-Way Interaction						
	Status x Prime Type x Target Frequency x Prime Frequency	(1, 17)	1.31	=0.27	(1, 17)	0.32	=0.58

Note. *F1* = Reaction Time; *F2* = Error Rate

Table 19

*The Results of the Paired Sample T-Tests Examining the U-E Priming Effect for Experiment 2b.*

Status	Target Frequency	Prime Frequency	Reaction Time				Error Rate			
			<i>M</i> Diff. (ms)	<i>df</i>	t value	<i>p</i> value	<i>M</i> Diff. (%)	<i>df</i>	t value	<i>p</i> value
Cognate	High	High	-31.51	18	-0.88	=0.39	0.00	18		
	Low	Low	-5.5	18	-0.2	=0.84	1.05	18	-0.44	=0.67
	High	Low	10.66	18	0.51	=0.62	2.11	18	-0.81	=0.43
	Low	High	-4.59	18	0.18	=0.86	5.26	18	0.56	=0.58
Noncognate	High	High	10.99	18	0.52	=0.61	2.11	18	1.46	=0.16
	Low	Low	-47.22	18	-1.59	=0.13	0.00	18	0.00	=1.00
	High	Low	66.53	18	3.11	<0.05	0.00	18	0.00	=1.00
	Low	High	25.22	18	0.62	=0.54	6.32	18	1.03	=0.32

particular interest is the priming effect (RTs to target words primed by unrelated primes minus RTs to target words primed by translation primes) obtained for cognates and noncognates in each of the frequency conditions. The planned comparison statistics are shown in Table 19.

**Analysis of Variance.** There was no main effect for Status, for Prime Type, or for Prime Frequency. There was a main effect of Target Frequency such that high-frequency words have shorter response latencies than low-frequency words.

There was an interaction between Status and Prime Frequency. A post hoc simple effects analysis revealed that when Prime Frequency was high, RTs to cognates were longer than RTs to noncognates,  $F(1, 17) = 5.93, p < 0.05$ . On the other hand, when Prime Frequency was low, RTs to noncognates were longer than RTs to cognates,  $F(1, 17) = 16.99, p < 0.05$ . This interaction is shown in Figure 26.

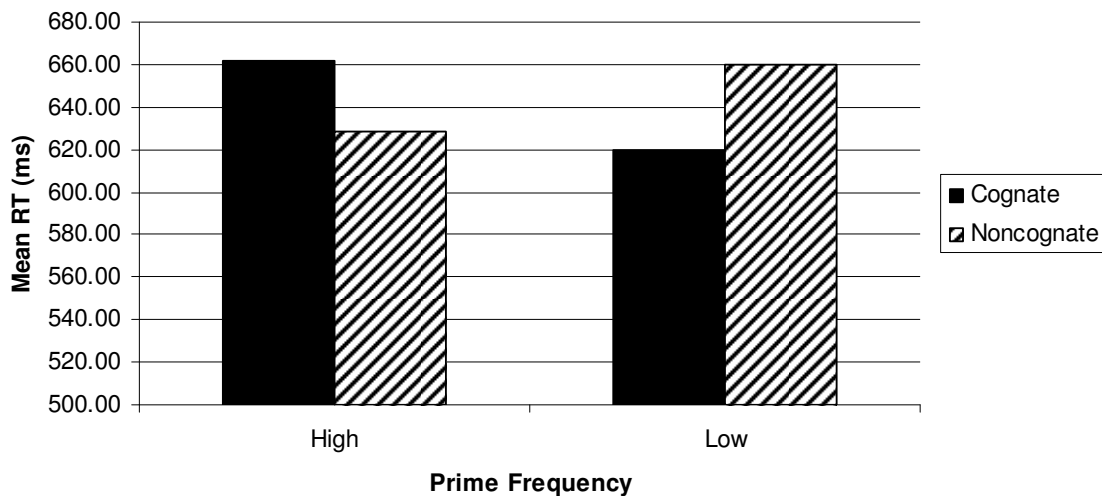


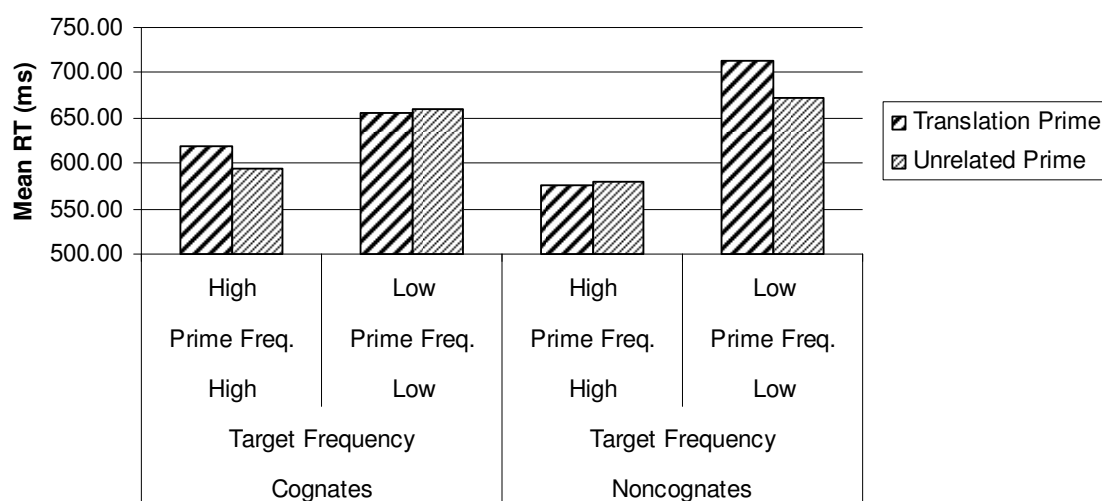
Figure 26. Interaction graph for Status and Prime Frequency.



There were no other two-way, three-way, or four-way interactions.

**Planned comparisons.** A series of paired sample t-tests were conducted. The t-test statistics are presented in Table 19.

*Frequency-balanced translation pairs.* There was no priming effect for any of the frequency-balanced translation pairs. Figure 27 shows the mean RT in milliseconds and Figure 28 shows the priming effect in milliseconds for cognates and noncognates for each of the prime-target frequency-balanced conditions.



*Figure 27.* Mean RT (ms) for cognates and noncognates for each of the frequency-balanced conditions when targets were preceded by translation primes and when they were preceded by unrelated primes.

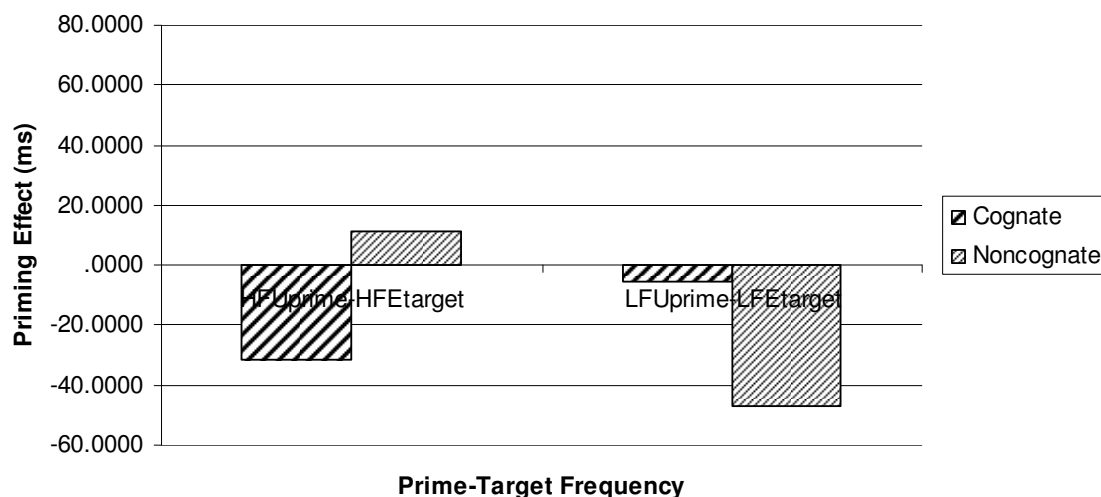
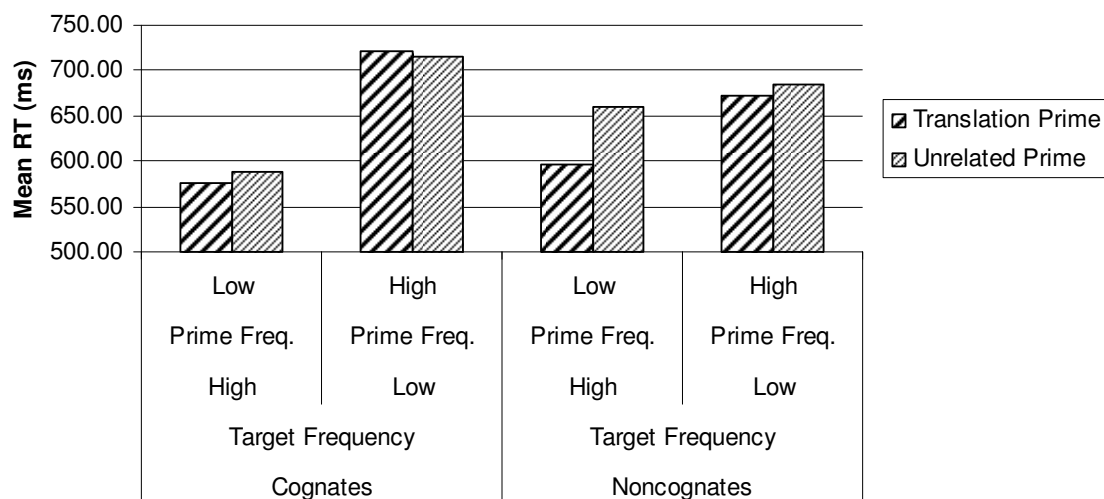
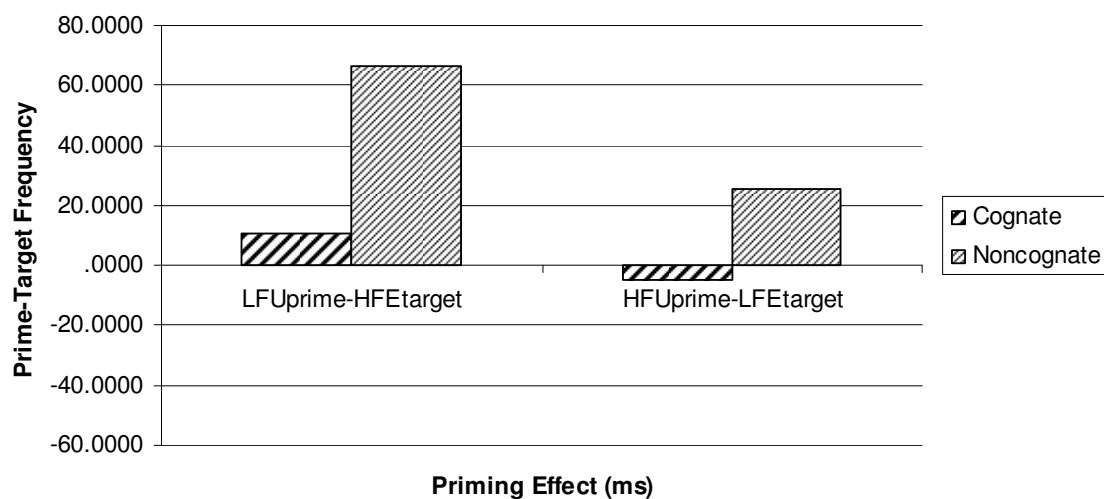


Figure 28. Cross-language priming effect for high-frequency Urdu (HFU) and high-frequency English (HFE), and low-frequency Urdu (LFU) and low-frequency English (LFE) prime-target pairs.

*Frequency-unbalanced translation pairs.* There was a priming effect for high-frequency noncognate words with low-frequency Urdu translations. There was no priming effect for any of the other frequency-unbalanced translation pairs. Figure 29 shows the mean RT in milliseconds and Figure 30 shows the priming effect in milliseconds for cognates and noncognates for each of the prime-target frequency-unbalanced conditions.



*Figure 29.* Mean RT (ms) for cognates and noncognates at each of the frequency-unbalanced conditions when targets were preceded by translation primes and when they were preceded by unrelated primes.



*Figure 30.* Cross-language priming effect for low-frequency Urdu (LFU) and high-frequency English (HFE), and low-frequency Urdu (LFU) and low-frequency English (LFE) prime-target pairs.

The difference between the priming effect for cognates and noncognates at each of the frequency levels was also examined using a series of t-tests. There was a difference in the priming effect for cognates and noncognates in the high-frequency condition with low-frequency primes,  $t(18) = 2.728$ ,  $p = 0.014$ , such that the noncognate priming effect was larger. There was no difference in the priming effect for cognates and noncognates in the high-frequency condition with high-frequency primes,  $t(18) = 0.877$ ,  $p = 0.392$ ; in the low-frequency condition with high-frequency primes,  $t(18) = 0.709$ ,  $p = 0.487$ ; and in the low-frequency condition with low-frequency primes,  $t(18) = -1.136$ ,  $p = 0.271$ .

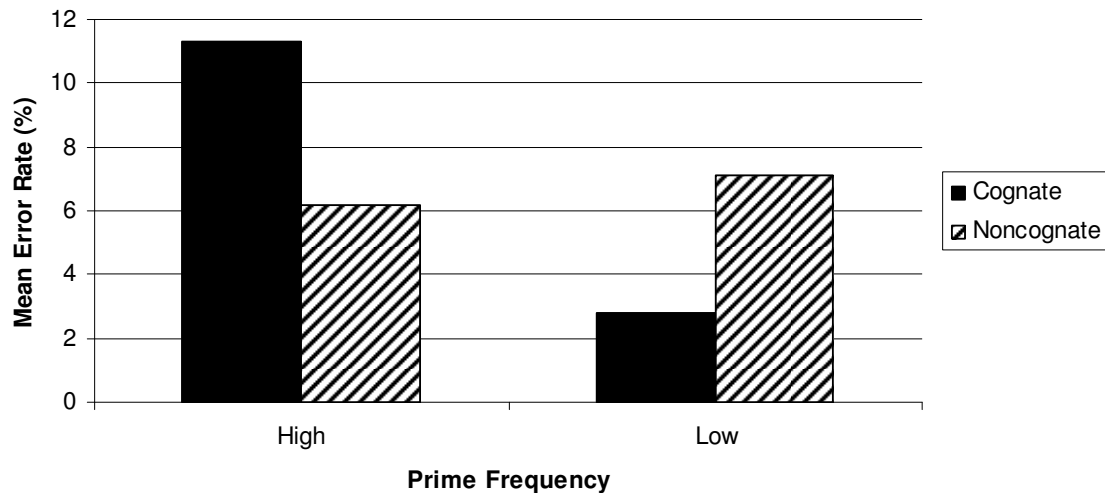
### **Error Rate**

**Subject Analysis.** An ANOVA was carried out, which consisted of the following variables: Group (List 1 versus List 2), Status (cognate versus noncognate), Prime Type (identity versus unrelated), Target Frequency (high versus low), and Prime Frequency (high versus low). The first variable was introduced by the counterbalancing procedure and extracted any variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach). The ANOVA statistics are reported in Table 18. However, of particular interest is the priming effect (i.e., the error rate for target words preceded by unrelated primes minus the error rate for target words preceded by translation primes). These planned comparison statistics are reported in Table 19.

There was no main effect for Status and of Prime Type. There was a main effect of Target Frequency such that high-frequency words were recognized more accurately

than low-frequency words. There was also a main effect of Prime Frequency such that low-frequency words were recognized more accurately than high-frequency words.

There was an interaction between Status and Prime Frequency. Post hoc simple effects analysis revealed that when Prime Frequency was high, more errors were made to cognate words than to noncognate words,  $F(1, 17) = 8.189, p < 0.05$ . However, when the Prime Frequency was low, more errors were made to noncognate words than to cognate words,  $F(1, 17) = 5.419, p < 0.05$ . This interaction is shown in Figure 31.



*Figure 31.* Mean percentage Error Rate for cognate and noncognate words as a function of Prime Frequency (high vs. low).

There was also an interaction between Target Frequency and Prime Frequency. Post hoc simple effects analysis revealed that fewer errors were made to high-frequency target words with high-frequency primes compared to high-frequency target words with low-frequency primes,  $F(1, 17) = 10.757, p < 0.05$ . On the other hand, when Target Frequency was low, fewer errors were made when Prime Frequency was also low

compared to when Prime Frequency was high,  $F(1, 17) = 23.915, p < 0.05$ . The interaction graph is shown in Figure 32.

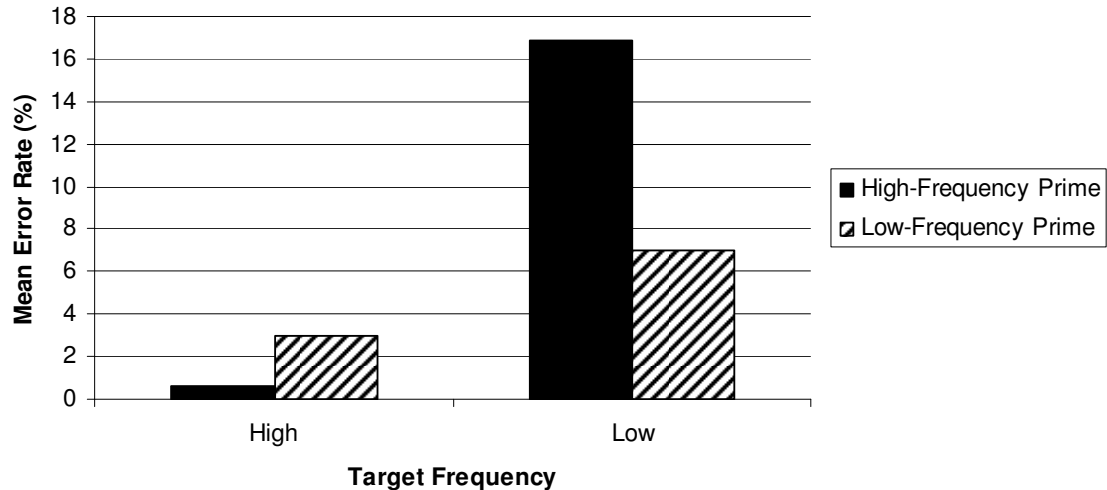
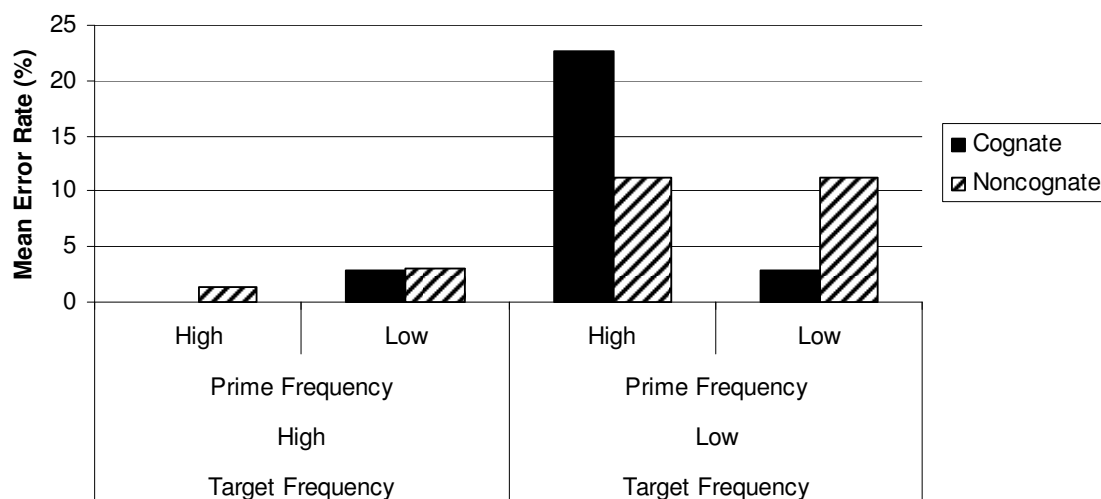


Figure 32. Interaction graph for Target Frequency and Prime Frequency.

There were no other two-way interactions.

There was a three-way interaction between Status, Target Frequency, and Prime Frequency. Figure 33 shows that fewer errors were made to cognate than to noncognate words when both Target Frequency and Prime Frequency were low (mean error rate = 2.8 % and 11.2 %, respectively). However, when Target Frequency was low and Prime Frequency was high, more errors were made to cognate than to noncognate words (mean error rate = 22.6 % and 11.2 %, respectively). When Target Frequency was high, there was very little difference in error rates for cognates and noncognate regardless of the Prime Frequency (mean error rate range = 0 to 3.1%).



*Figure 33.* Interaction graph for percentage Error Rate for Status, Target Frequency, and Prime Frequency.

There were no other three-way and four-way interactions.

A series of paired sample t-tests revealed that there was no priming effect for any of the conditions.

### Discussion

The purpose of the within language (E-E) condition was to confirm that these participants can process and benefit from a 30 ms masked English prime. The results indicate that these bilinguals were unable to process and benefit from a 30 ms English prime even though in the previous experiment (Experiment 2a) within language (E-E) priming was obtained indicating that those participants were able to process and benefit from a 30 ms masked English prime. These results suggest that within language masked priming effect is unstable at the 30 ms prime duration. The failure to obtain within

language priming in English means that no conclusions can be drawn from the cross-language English-Urdu translation priming condition.

The goal of the cross-language (DL-NL) translation priming was to test the hypothesis proposed by Kim and Davis (2003) and Voga and Grainger (2007) that differences in word frequency resulted in the discrepancy in findings by Gollan et al. (1997), Kim and Davis, and Voga and Grainger. As within language priming in English was not obtained at the 30 ms prime duration, no conclusions can be drawn from the results of the English-Urdu cross-language condition where English primes were presented for 30 ms. Therefore, in the following experiment (Experiment 2c), the English prime duration is increased to 50 ms in order to increase the likelihood of within- and cross-language priming.

As stated above, the purpose of the within language (U-U) condition was twofold. First, masked priming in Urdu has not been demonstrated previously. Therefore, it is important to replicate the masked priming effect within Urdu before attempting to use Urdu primes in cross-language priming. Second, it is important to show that participants benefit from a 50 ms NL prime in the NL-NL within language condition before attempting to interpret the results from NL-DL cross language priming. The results confirm that within language masked priming occurs for the Urdu language. They also confirm that participants can process and benefit from a 50 ms masked Urdu prime.

The goal of the Urdu-English (NL-DL) cross-language translation priming study was to replicate the findings of Gollan et al. (1997) who used low-frequency words and found no cognate and noncognate priming in the L2-L1 priming direction (the overall priming effect when cognate and noncognate conditions were combined, however, was



significant when Hebrew-dominant bilinguals, who were more balanced in terms of proficiency, were tested, but not when English-dominant bilinguals were tested). Further, I wanted to examine how high-frequency NL-DL prime-target translation pairs and frequency unbalanced NL-DL prime-target translation pairs are processed.

Like Gollan et al. (1997), the cognate and noncognate priming effect obtained in the NL-DL condition for low-frequency words was not statistically significant. It is interesting to note that although not statistically significant, the size of the priming effect for the noncognate low-frequency prime-target condition was quite large (-47.2 ms) and was in the reverse direction. The statistically nonsignificant priming effect obtained in the cognate low-frequency prime-target condition, on the other hand, was quite small (-5.5 ms) although it was still in the reverse direction. In Gollan et al.'s study the priming effect for Hebrew-dominant bilinguals was statistically nonsignificant and of the same size (9 ms) for both cognates and noncognates. For English-dominant bilinguals the nonsignificant priming effect for cognates (4 ms) and noncognates (-4 ms) was again the same size but in opposite directions.

The cognate and noncognate priming effect obtained in the NL-DL condition for high-frequency words was also statistically nonsignificant. Again, it is interesting to note that although nonsignificant, the size of the priming effect for the cognate high-frequency prime-target condition was sizable (-31.6 ms) and was in the reverse direction. The nonsignificant priming effect for the noncognate high-frequency prime-target condition, on the other hand, was smaller (11.0 ms) and in the positive direction.

Overall, there was no cognate or noncognate priming effect for low- and high-frequency prime-target translation pairs in the NL-DL priming direction for frequency-

balanced prime-translation pairs. This finding was consistent with the results obtained by Gollan et al. (1997) for the L2-L1 priming direction.

In the frequency-unbalanced conditions, high-frequency noncognate words primed by low-frequency translations showed a priming effect (66.6 ms). However, cognate words in this frequency condition did not show a statistically significant priming effect (10.7 ms). In addition, there was no statistically significant priming effect in the NL-DL priming direction for low-frequency cognate (-4.6 ms) and noncognate words (25.2 ms) with high-frequency primes.

These findings are unusual in that a noncognate priming effect in the NL-DL (or L2-L1) direction has not been previously reported for cross-script translation pairs. Furthermore, enhanced noncognate priming relative to cognate priming is unlike previous findings (although Kim and Davis, 2003, reported a slightly higher noncognate priming effect for high-frequency prime-target pairs in the L1-L2 direction). Lastly, noncognate priming for low-frequency prime high-frequency target word pairs is even more unusual if the frequency effect is likened to the proficiency effect as has been done previously (e.g., Bijeljac-Babic, Biardieu, & Grainger, 1997). This is because a low-frequency prime in L2 should bring about even weaker activation than a low-frequency prime in L1, thereby significantly reducing the chances of a priming effect from emerging. One possible explanation is that these bilinguals are very proficient in the NL (Urdu), so much so that it is not a “NL” at all. In that case, NL primes may be very strongly activated thereby bringing about a noncognate priming effect based on enhanced semantic activation. This explanation, however, does not clarify why there is no cognate priming effect obtained for the same frequency condition. One possible explanation is that high-

frequency cognate targets are processed too quickly in English (DL) to allow the low-frequency Urdu (NL) primes to influence their processing. This explanation was offered by Gollan et al. (1997) to explain the lack of priming for both cognates and noncognates in the L2-L1 priming direction. Alternately, it is possible that there is inhibition preventing a cognate effect from emerging. Bijeljac-Babic, Biardieu, and Grainger (1997) found that proficiency in the nondominant language has an analogous effect to word frequency and that higher language proficiency results in stronger inhibition. Thus, even though low-frequency primes were used, perhaps the high-proficiency of the participants led to stronger inhibition for cognates. It is important to note that this explanation implies that for cross-script cognates, the inhibitory effect is at the phonological level despite facilitation at the semantic level due to semantic overlap. For cross-script noncognate translation pairs there is facilitation at the semantic level due to semantic overlap but no inhibition at the phonological level. This point will be further discussed in the General Discussion. In addition, language proficiency of the bilingual participants is an important variable and this point will also be discussed below.

Overall, these results suggest that perhaps cross-script frequency-unbalanced prime-target translation pairs are processed differently than cross-script frequency-balanced prime-target translation pairs in the NL-DL priming direction. This proposal needs to be further investigated particularly because cognate or noncognate priming was not obtained for the high-frequency prime low-frequency target translation pairs.

Gollan et al. (1997) proposed that the absence of a cognate priming effect in the L2-L1 direction indicates that the mechanism responsible for translation priming is different for same-script and cross-script bilinguals. Their proposal was based on the

findings of previous same-script studies that showed a robust cognate priming effect in both the L1-L2 and L2-L1 direction. Gollan et al. proposed that bidirectional enhanced priming is dependant on the translation pairs sharing a common script. In the current experiment, a statistically significant cognate or noncognate priming effect was not obtained for low-frequency prime-target pairs or high-frequency prime-target pairs. In addition, a statistically significant priming effect was not obtained for low-frequency cognate and noncognate words with high-frequency primes. However, high-frequency words with low-frequency noncognate primes did show a priming effect in the NL-DL priming direction. This finding suggests the possibility that frequency-unbalanced prime-target pairs may be processed differently than frequency-balanced cross-script translation pairs. No priming effect was obtained, however, for the high-frequency cognate words with low-frequency primes. It may be that high-frequency cognate targets are processed too quickly in English (DL) to allow the low-frequency Urdu (NL) primes to influence their processing. It is also possible that an inhibitory process may be at play for cognate processing when NL-DL prime-target word pairs are not balanced on frequency. However, the lack of cognate or noncognate priming for the other frequency unbalanced condition cannot be explained by this proposal, which requires further investigation.

It is interesting to note that sizable priming in some of the frequency conditions is not statistically significant. This may be because of the high variance in RTs across the participants due to variable levels of language proficiency or different response strategies adopted by the participants. These points will be taken up in the General Discussion.

## **CHAPTER V**

### **Experiment 2c**

#### **Masked Priming from English to Urdu (DL-NL) at 50 ms SOA Using Frequency-Balanced and Frequency-Unbalanced Cognates and Noncognates**

#### **Method**

##### **Participants**

Twenty-five Urdu-English bilinguals participated in this study. These participants were recruited from the same pool as Experiment 1.

##### **Materials and Apparatus**

Two of the experimental lists used in Experiment 2b were used in this experiment (see Appendix A for the stimulus set). One of these lists was a within-language priming list in English consisting of English primes followed by English targets (E-E). The other list was a cross-language priming list such that Urdu targets were preceded by English primes (E-U). A set of sixteen prime-target pairs was presented in the practice trial prior to the experimental stimuli. Half the target items were words and the other half were nonwords.

The apparatus used was the same as that used for Experiment 2b.

##### **Procedure**

Participants were tested individually and completed a test of reading proficiency in Urdu, which involved reading a passage in Urdu for one minute. Next, they completed a lexical decision task where they were told to determine as quickly and accurately as possible, if the presented letter strings were real words or not. They were told to press the “/” key if the presented string was a word and the “Z” key if it was not a word.

Instructions for each of the lists were given in the same language as the target words for that list and the participants were allowed to rest briefly after completing the first list. Sixteen practice trials were presented before the experimental lists in order for the experimenter to observe the participants' performance and encourage quick but accurate responses.

Each trial consisted of the presentation of a forward mask in the center of the screen for 500 ms. The forward mask comprised of a string of hash marks (e.g., #####). The length of this string was matched to the length of the prime word in order to successfully mask the prime. This was immediately followed by the presentation of the prime for 50 ms. The prime was followed by the target word and remained on the screen until the participant made a response. The RT was measured from the onset of the target to when the subject pressed the response button.

After the completion of the lexical decision task, participants were asked whether they were able to read and understand all of the stimulus material presented in the experiment. They were also asked whether they saw any prime words in the experiment. The participants then completed a test of reading proficiency in English, which involved reading an English passage for one minute. A language background questionnaire was then given to the participants in order to further assess their language proficiency. This language questionnaire was the same as the one presented in Experiments 2a and 2b.

## **Results**

Twenty-five participants were tested in this experiment. Three of the participants reported awareness of the prime on the exit interview and were thus excluded from the analysis. One of the participants made more than 20% errors (averaged across the Within

Language and Cross Language conditions) and was also removed from the analysis.

Thus, data from twenty-one participants formed the basis of the analysis in this experiment.

### **Language Fluency**

A series of paired sample t-tests indicated that reading proficiency for participants in Experiment 2c, as indicated by the number of words read within a specified period of time and the number of errors made, was higher for English than for Urdu,  $t(20) = 10.423, p < 0.05$ , and  $t(20) = -5.087, p < 0.05$ , respectively. Self-reported language proficiency averaged across the domains of speaking, comprehension, reading, and writing was also higher for English than for Urdu,  $t(20) = 2.568, p < 0.05$ . See Table 20 for a summary of the results from the Language Questionnaire.

Table 20

*Language History (Scale 1=Only Urdu, 2=Urdu > English, 3=Urdu=English, 4=English>Urdu; 5=Only English) and Self-assessed Urdu and English Proficiency Ratings (From 1=Nonfluent to 7=Native Fluency).*

Proficiency Measure		Minimum	Maximum	Mean	
Proficiency (1-7)					
Proficiency (1-7)	Urdu		4	7	5.8
		Speaking	3	7	5.56
		Comprehension	3	7	5.24
		Reading	2	7	4.84
		Writing			
	English				
		Speaking	4	7	5.80
		Comprehension	4	7	5.96
		Reading	5	7	6.16
		Writing	4	7	5.92
	Language Use (1-5)				
Language Use (1-5)		Speaking	2	5	3.19
		Listening	2	5	3.29
		Reading	3	5	4.23
		Writing	3	5	4.19
Age of Acquisition (years old when began acquiring language)					
Age of Acquisition (years old when began acquiring language)	Urdu	0	5.50	1.31	
	English	0	2.5	3.14	

### Within Language Priming in English (E-E)

#### Data Treatment

After removing incorrect responses (4.05% of data), lower and upper absolute cut-off limits were set at 200ms and 2000ms respectively. This resulted in removal of 2.26% of the data. Reaction times greater than two standard deviations above and below the mean for each participant for each condition were replaced with the appropriate cut-



off value. This treatment was applied to 5% of the data. Mean lexical decision times were subsequently calculated for each of the conditions and this data is presented in

Table 21.

Table 21

*Mean Lexical Decision Times (in Milliseconds) and Percent Error Rates Obtained for Within-Language English (HFE-HFE, LFE-LFE) Priming Lists in Exp 2c.*

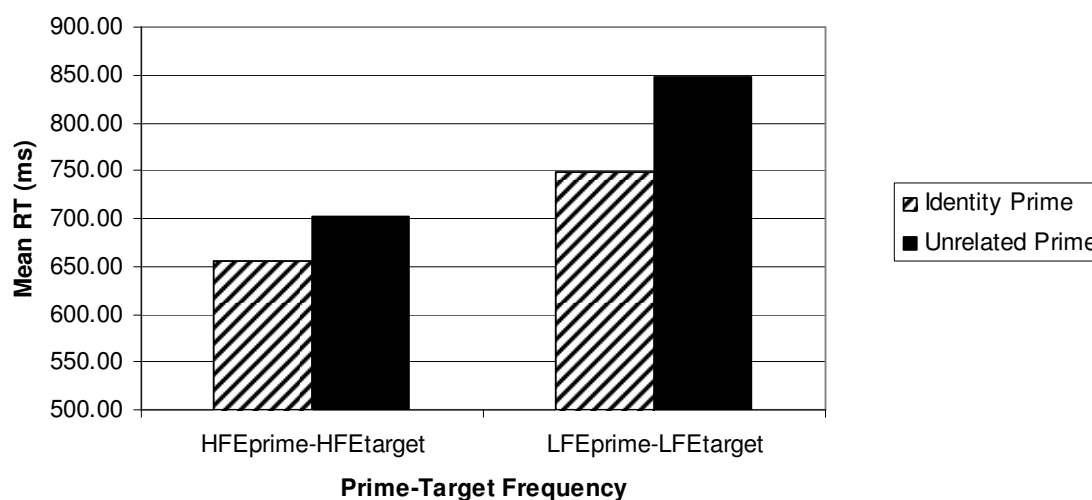
Condition	RT	% Error
HFE-HFE		
Repetition	655.46	0.48
Control	701.85	1.90
Priming	46.39	1.43
LFE-LFE		
Repetition	749.51	6.67
Control	847.22	7.14
Priming	97.72	0.48

## Reaction Time

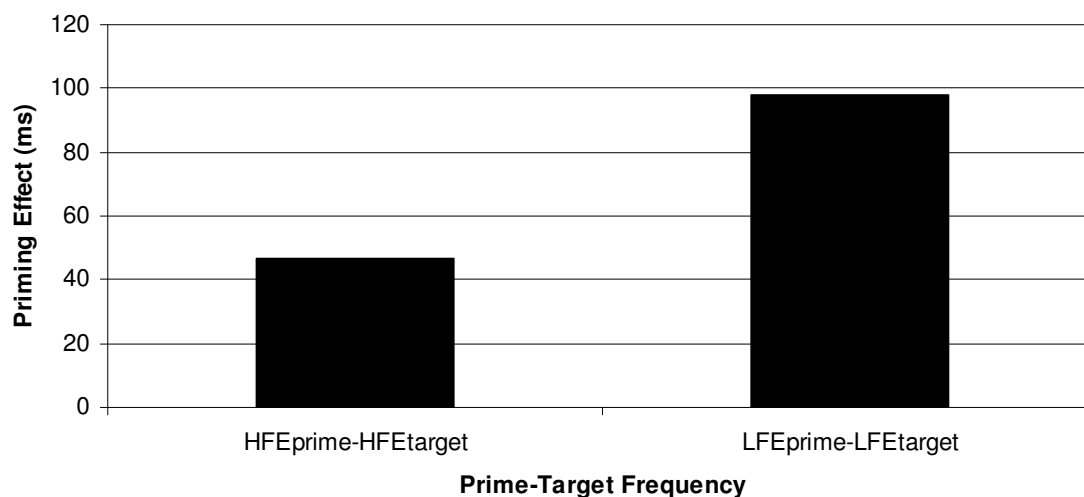
**Subject Analysis.** An ANOVA was carried out, which consisted of the following variables: Group (List 1 versus List 2), Prime Type (identity versus unrelated), and Frequency (high versus low). The first variable, a between-subjects variable, was introduced by the counterbalancing procedure and extracted any variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach). All other variables were treated as within-subject variables. The ANOVA statistics are presented in Table 22.

There was a main effect of Prime Type such that repetition priming resulted in shorter response latencies compared to priming with unrelated words. There was also a main effect of Frequency such that high-frequency words had shorter response latencies compared to low-frequency words. There was no interaction between Prime Type and Frequency.

A series of paired sample t-tests (see Table 23 for t-test statistics) revealed that there was a within language priming effect for both high-frequency and low-frequency words. This is shown in Figures 34 and 35.



*Figure 34.* Within-Language RT latencies (ms) for high-frequency English (HFE) and low-frequency English (LFE) prime-target pairs.



*Figure 35.* Within-language priming effect for high-frequency English (HFE) and low-frequency English (LFE) prime-target pairs.

Table 22

*The Results of 2 (Prime Type: Identity Vs. Unrelated) x 2 (Frequency: High Vs. Low) Repeated Measures Analysis of Variance for Experiment 2c.*

Language	Effect	Reaction Time			Error Rate		
		<i>df</i>	<i>F1</i> value	<i>p</i> value	<i>df</i>	<i>F2</i> value	<i>p</i> value
English-English							
	Main Effect						
	Prime Type	(1, 19)	13.6	<0.05	(1, 19)	0.27	=0.61
	Frequency	(1, 19)	26.12	<0.05	(1, 19)	15.67	<0.05
	Two-Way Interaction						
	Prime Type x Frequency	(1, 19)	0.88	=0.36	(1, 19)	0.66	=0.43

Note. *F1* = Reaction Time; *F2* = Error Rate

Table 23

*The Results of the Paired Sample T-Tests Examining the Priming Effect for Experiment 2c.*

Language	Target Frequency	Prime Frequency	Reaction Time				Error Analysis			
			<i>M</i> Diff. (ms)	<i>df</i>	<i>t</i> value	<i>p</i> value	<i>M</i> Diff.(%)	<i>df</i>	<i>t</i> value	<i>p</i> value
English-English										
	High	High	46.39	20	2.15	<0.05	1.43	20	1.37	=0.19
	Low	Low	97.72	20	3.02	<0.05	0.48	20	0.21	=0.83

M Diff. = Mean Difference

## **Error Rate**

**Subject Analysis.** An ANOVA was carried out, which consisted of the following variables: Group (List 1 versus List 2), Prime Type (identity versus unrelated), and Frequency (high versus low). The first variable was introduced by the counterbalancing procedure and extracted any variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach). The ANOVA statistics are presented in Table 22.

There was no main effect of Prime Type. However, there was a main effect of Frequency such that fewer errors were made to high-frequency words than to low-frequency words. There was no interaction between Prime Type and Frequency.

A series of paired sample t-tests (see Table 23 for statistics) revealed that there was no within language priming effect for both high-frequency and low-frequency words.

## **Discussion**

The results confirm that the bilingual participants in the current experiment were sufficiently proficient in English to benefit from a 50 ms English prime.

### **Cross Language Priming from English to Urdu (E-U)**

#### **Data Treatment**

After removing incorrect responses (12.8% of data), lower and upper absolute cut-off limits were set at 200ms and 2000ms respectively. This resulted in removal of 7.74% of the data. Reaction times greater than two standard deviations above and below the mean for that condition across all participants were replaced with the appropriate cut-off value. This treatment was applied to 0% of the data. Mean lexical decision times

were subsequently calculated for each of the conditions and this data is presented in Table 24.

Table 24

*Mean Lexical Decision Times (in Milliseconds) and Percent Error Rates Obtained for Cross-Language English-Urdu (HFE-HFU, LFE-LFU, HFE-LFU, LFE-HFU) Priming Lists in Experiment 2c.*

Condition	Target			
	Cognate		Noncognate	
	Mean	% Error	Mean	% Error
HFE-HFU				
Translation	879.08	0.95	853.03	3.81
Control	871.10	4.76	904.54	6.67
Priming	-7.98	3.81	51.51	2.86
LFE-LFU				
Translation	1118.11	8.57	1077.56	14.29
Control	1168.97	18.10	1093.21	5.71
Priming	50.85	9.53	15.65	-8.58
LFE-HFU				
Translation	892.40	7.62	1041.64	7.62
Control	1004.81	9.52	1010.67	14.29
Priming	112.41	1.90	-30.97	6.67
HFE-LFU				
Translation	975.19	20.00	984.01	33.33
Control	1077.94	17.14	1085.67	32.38
Priming	102.75	-2.86	101.66	-0.95

## Reaction Time

**Subject Analysis.** An ANOVA was carried out, which consisted of the following variables: Group (List 1 versus List 2), Status (cognate versus noncognate), Prime Type (identity versus unrelated), Target Frequency (high versus low), and Prime Frequency (high versus low). The first variable was introduced by the counterbalancing procedure and extracted any variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach). The ANOVA statistics are presented in Table 25. However, of particular

interest is the priming effect obtained in each of the frequency conditions. Statistics for the planned comparisons are presented in Table 26.

Table 25

*The Results of 2 (Status: Cognate Vs. Noncognates) x 2 (Prime Type: Translation Vs. Unrelated) x 2 (English Frequency: High Vs. Low) x 2 (Urdu Frequency: High Vs. Low) Repeated Measures Analysis of Variance for Experiment 2c.*

Language	Effect	Reaction Time			Error Rate		
		<i>df</i>	<i>F1</i> value	<i>p</i> value	<i>df</i>	<i>F2</i> value	<i>p</i> value
English-Urdu	Main Effect						
	Status	(1, 19)	0.17	=0.69	(1, 19)	7.25	<0.05
	Prime Type	(1, 19)	3.87	=0.06	(1, 19)	0.83	=0.37
	Target Frequency	(1, 19)	64.31	<0.05	(1, 19)	66.87	<0.05
	Prime Frequency	(1, 19)	13.12	<0.05	(1, 19)	7.36	<0.05
	Two-Way Interaction						
	Status x Prime Type	(1, 19)	1.27	=0.27	(1, 19)	0.84	=0.37
	Status x Target Frequency	(1, 19)	4.17	=0.06	(1, 19)	2.21	=0.15
	Status x Prime Frequency	(1, 19)	0.02	=0.90	(1, 19)	14.62	<0.05
	Prime Type x Target Frequency	(1, 19)	1.38	=0.26	(1, 19)	4.61	<0.05
	Prime Type x Prime Frequency	(1, 19)	0.50	=0.49	(1, 19)	0.12	=0.73
	Target Frequency x Prime Frequency	(1, 19)	0.76	=0.40	(1, 19)	43.27	<0.05
	Three-Way Interaction						
	Status x Prime Type x Target Frequency	(1, 19)	0.02	=0.88	(1, 19)	0.35	=0.56
	Status x Prime Type x Prime Frequency	(1, 19)	1.12	=0.30	(1, 19)	9.99	<0.05
	Status x Target Frequency x Prime Frequency	(1, 19)	3.50	=0.08	(1, 19)	24.24	<0.05
	Prime Type x Target Frequency x Prime Frequency	(1, 19)	2.03	=0.17	(1, 19)	0.08	=0.79
	Four-Way Interaction						
	Status x Prime Type x Target Frequency x Prime Frequency	(1, 19)	3.53	=0.08	(1, 19)	9.72	<0.05

Note. *F1* = Reaction Time; *F2* = Error Rate

Table 26

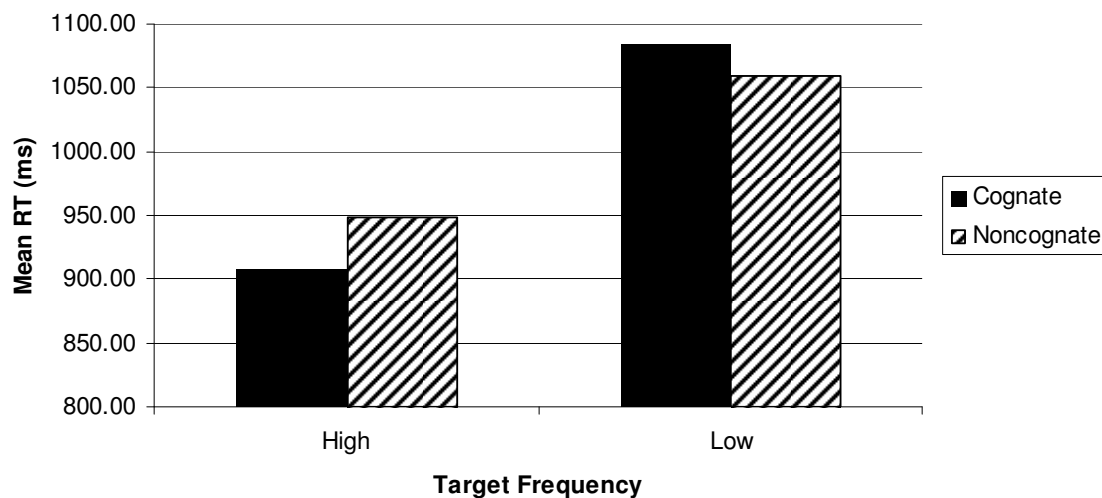
*The Results of the Paired Sample T-Tests Examining the U-E Priming Effect for Experiment 2c.*

Status	Target Frequency	Prime Frequency	Reaction Time				Error Rate			
			<i>M</i> Diff. (ms)	<i>df</i>	t value	<i>p</i> value	<i>M</i> Diff. (%)	<i>df</i>	t value	<i>p</i> value
Cognate										
	High	High	-7.98	20	-0.15	=0.88	3.81	20	1.71	=0.10
	Low	Low	50.85	20	0.79	=0.44	9.52	20	2.23	<0.05
	High	Low	112.42	20	2.31	<0.05	2.86	20	-0.57	=0.58
	Low	High	102.75	20	1.43	=0.17	1.91	20	0.57	=0.58
Noncognate										
	High	High	51.51	20	1.25	=0.23	2.86	20	0.90	=0.38
	Low	Low	15.65	20	0.30	=0.77	8.57	20	-2.12	<0.05
	High	Low	-30.97	20	-0.63	=0.54	0.95	20	-0.20	=0.84
	Low	High	101.66	20	1.94	=0.07	6.67	20	1.92	=0.07



There was no effect of Status. The main effect for Prime Type was approaching significance such that response latencies were shorter when target words were preceded by translation primes compared to when they were preceded by unrelated primes. There was a main effect of Target Frequency such that high-frequency words were responded to faster than low-frequency words. There was also a main effect of Prime Frequency such that response latencies were faster when targets were preceded by high-frequency primes rather than low-frequency primes.

The interaction between Status and Target Frequency was approaching significance. Post hoc simple effects analysis revealed that when the Target Frequency was low, cognates were recognized faster than noncognates,  $F(1,19) = 4.151, p = 0.056$ . On the other hand, when Target Frequency was high, there was no difference in RT latencies for cognates and noncognates,  $F(1,19) = 1.3, p = 0.268$ . This interaction is shown in Figure 36.

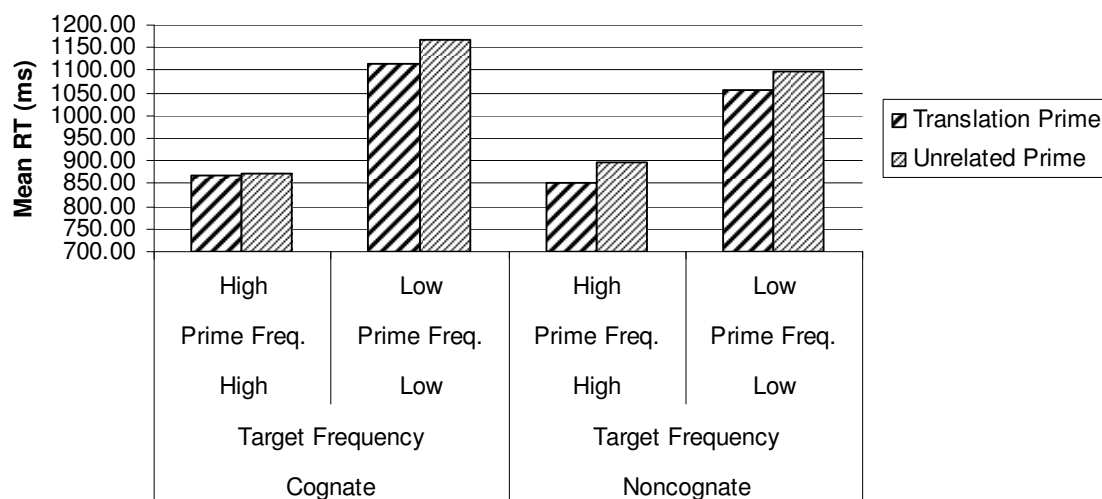


*Figure 36.* Mean reaction time in milliseconds for cognate and noncognate words as a function of Target Frequency (high vs. low).

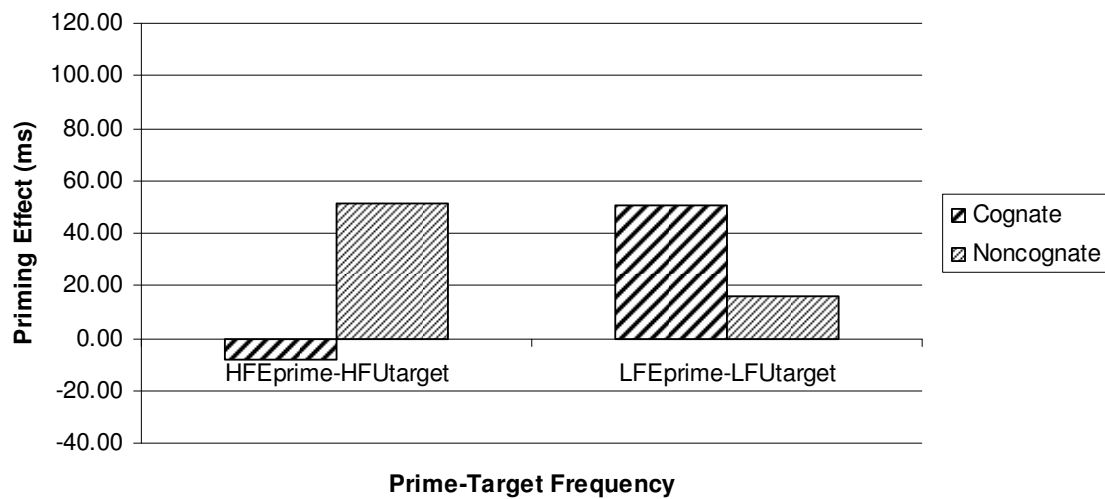
There were no other two-way, three-way, or four-way interactions.

**Planned comparisons.** A series of paired sample t-tests were conducted.

*Frequency-balanced translation pairs.* There was no priming effect for any of the frequency-balanced translation pairs. Figure 37 shows the mean RT in milliseconds and Figure 38 shows the priming effect in milliseconds for cognates and noncognates for each of the prime-target frequency conditions.

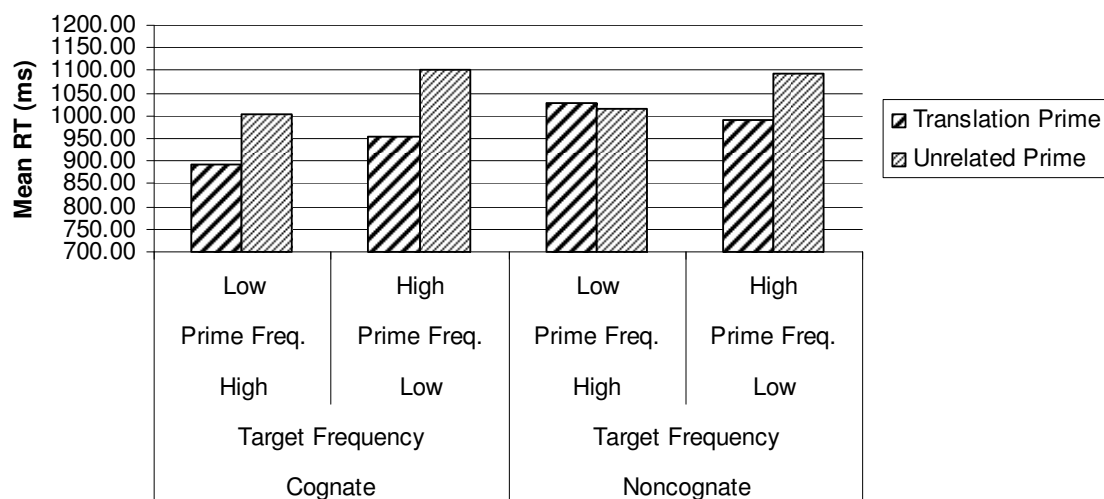


*Figure 37.* Mean RT (ms) for cognates and noncognates at each of the frequency-balanced conditions when targets were preceded by translation primes and when they were preceded by unrelated primes.

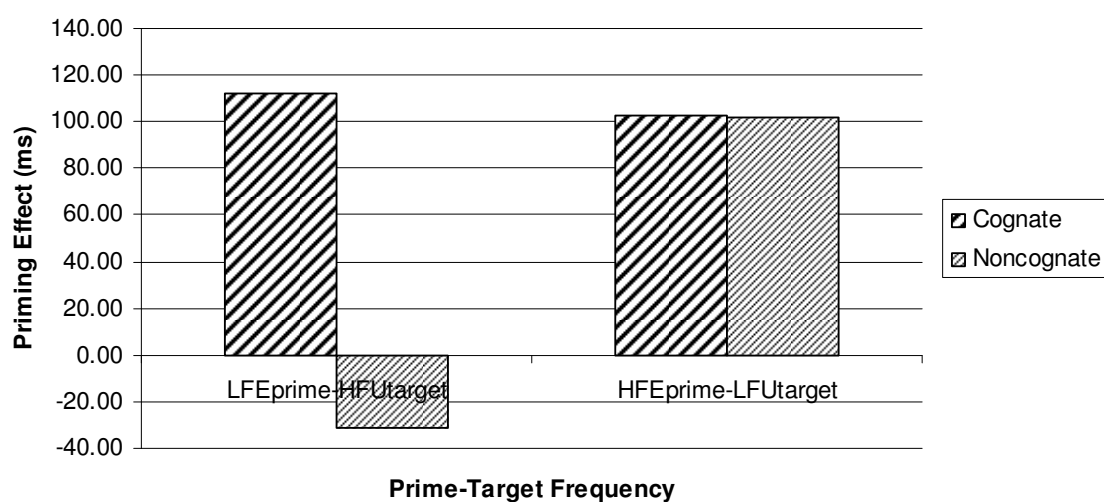


*Figure 38.* Cross-language priming effect for high-frequency English (HFE) and high-frequency Urdu (HFU), and low-frequency English (LFE) and low-frequency Urdu (LFU) prime-target pairs.

*Frequency-unbalanced translation pairs.* There was a priming effect for the high-frequency cognate condition with low-frequency primes. In addition, the priming effect was approaching significance for the low-frequency noncognate condition with high-frequency primes. There was no priming effect for any of the other frequency-unbalanced translation pairs. Figure 39 shows the mean RT in milliseconds and Figure 40 shows the priming effect in milliseconds for cognates and noncognates for each of the prime-target frequency conditions.



*Figure 39.* Mean RT (ms) for cognates and noncognates at each of the frequency-unbalanced conditions when targets were preceded by translation primes and when they were preceded by unrelated primes.



*Figure 40.* Cross-language priming effect for high-frequency English (HFE) and high-frequency Urdu (HFU), low-frequency English (LFE) and high-frequency Urdu (HFU), high-frequency English (HFE) and low-frequency Urdu (LFU), and low-frequency English (LFE) and low-frequency Urdu (LFU) prime-target pairs.

The difference between the priming effect for cognates and noncognates at each of the frequency levels was also examined using a series of t-tests. There was no difference in the priming effect for cognates and noncognates in the high-frequency condition with high-frequency primes,  $t(20) = 1.199, p = 0.245$ , and in the low-frequency condition with low-frequency primes,  $t(20) = -0.506, p = 0.618$ . The difference in the priming effect for cognates and noncognates in the high-frequency condition with low-frequency primes was approaching significance,  $t(20) = -2.31, p = 0.054$ . There was no difference in the priming effect between cognates and noncognates in the low-frequency condition with high-frequency primes,  $t(20) = -0.015, p = 0.988$ .

### **Error Rate**

**Subject Analysis.** An ANOVA was carried out, which consisted of the following variables: Group (List 1 versus List 2), Status (cognate versus noncognate), Prime Type (identity versus unrelated), Target Frequency (high versus low), and Prime Frequency (high versus low). The first variable was introduced by the counterbalancing procedure and extracted any variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach). The ANOVA statistics are presented in Table 25. However, of particular interest is the priming effect. See Table 26 for the t-test statistics from these.

There was an effect of Status such that fewer errors were made when target words were cognates than when they were noncognates. There was no main effect for Prime Type. There was a main effect of Target Frequency such that fewer errors were made to high-frequency target words than to low-frequency target words. There was also a main

effect of Prime Frequency such that more errors were made when targets were preceded by high-frequency primes rather than low-frequency primes.

There was an interaction between Prime Type and Target Frequency. Post hoc simple effects analysis revealed that fewer errors were made to high-frequency targets preceded by translation primes than those preceded by unrelated primes,  $F(1,19) = 3.77$ ,  $p = 0.067$ , whereas the error rate was similar for low-frequency targets preceded by translation and unrelated primes,  $F(1,19) = 0.101$ ,  $p = 0.754$ . This interaction is shown in Figure 41.

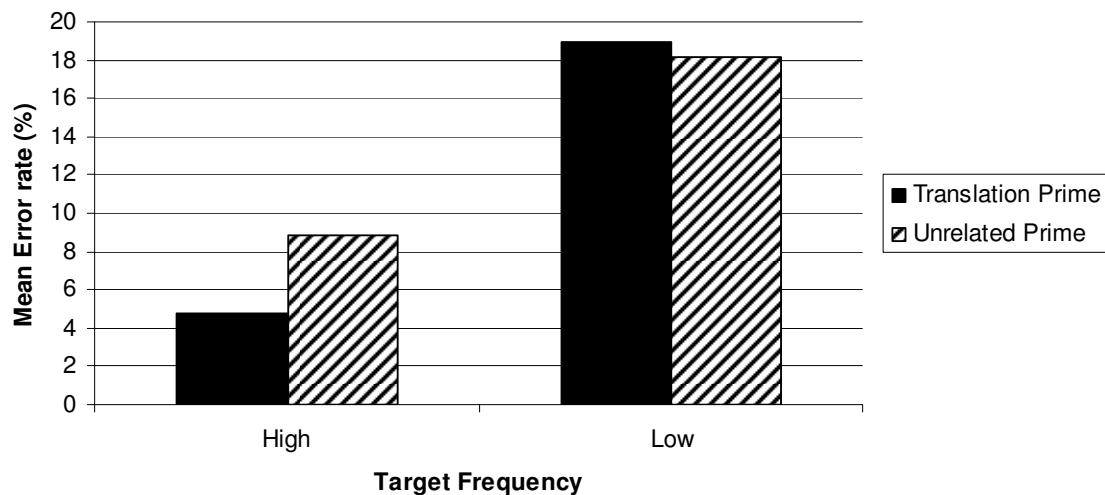


Figure 41. Interaction graph for Prime Type and Target Frequency.

There was an interaction between Status and Prime Frequency. Post hoc simple effects analysis revealed that when high-frequency primes were used more errors were made to noncognate than to cognate words,  $F(1,19) = 19.53$ ,  $p < 0.05$ . However, when

low-frequency primes were used the error rate for cognate and noncognates was similar,  $F(1,19) = 0.020$ ,  $p = 0.890$ . This interaction is shown in Figure 42.

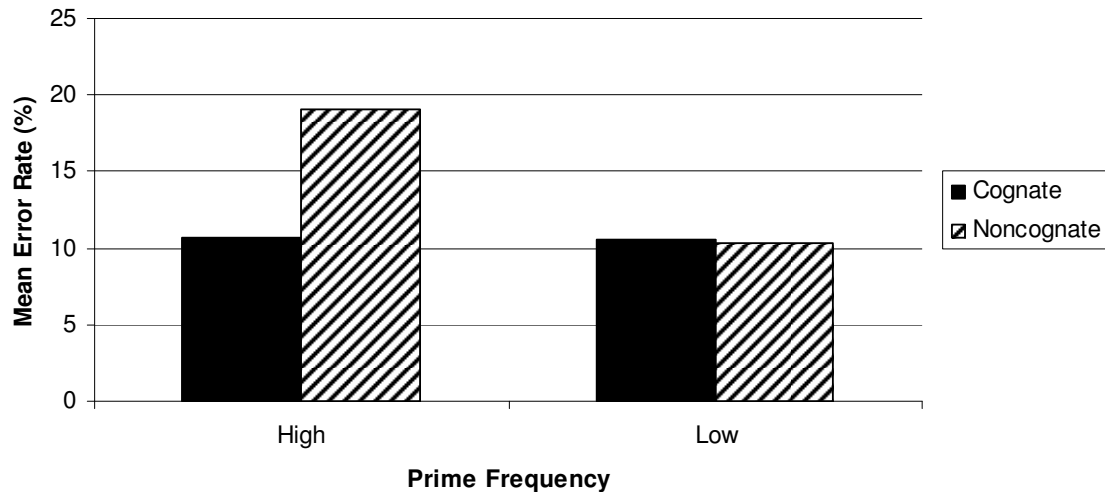
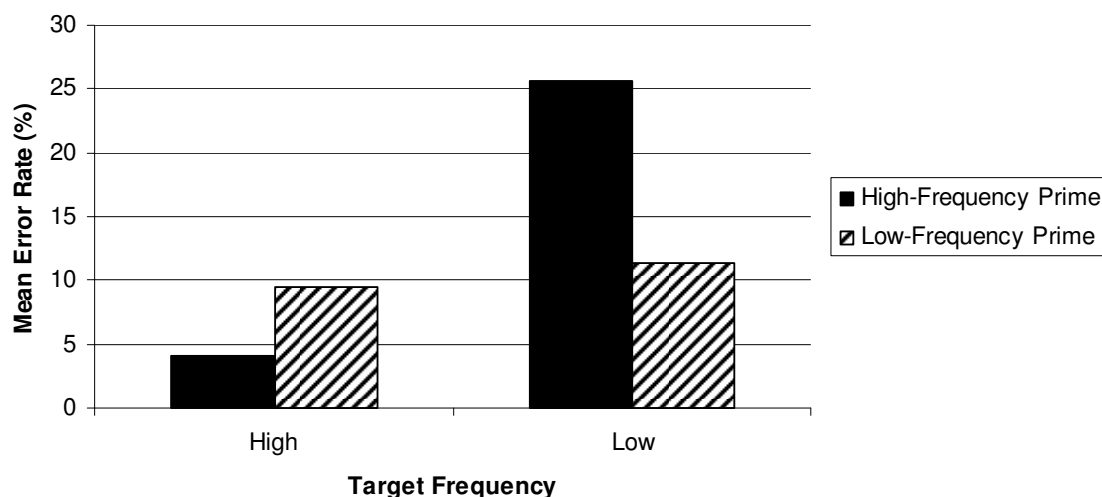


Figure 42. Mean percentage error rate for cognates and noncognates as a function of Prime Frequency (high vs. low).

There was also an interaction between Target Frequency and Prime Frequency. Post hoc simple effects analysis revealed that fewer errors were made to high-frequency target words preceded by high-frequency primes compared to when they were preceded by low-frequency primes,  $F(1,19) = 7.58$ ,  $p < 0.05$ . However, more errors were made to low-frequency target words preceded by high-frequency primes compared to when they were preceded by low-frequency primes,  $F(1,19) = 33.00$ ,  $p < 0.05$ . This interaction is shown in Figure 43.

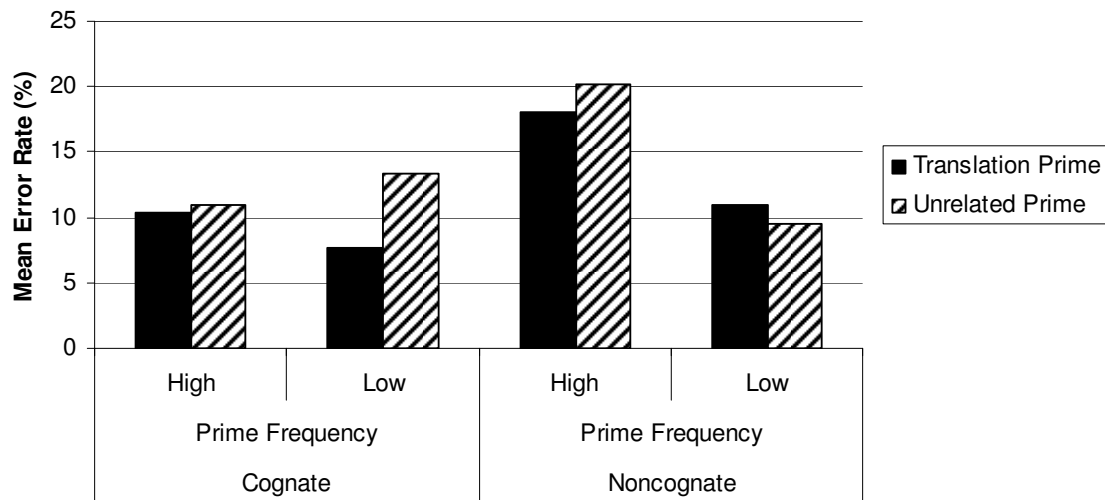


*Figure 43.* Interaction graph for Target Frequency and Prime Frequency.

There were no other two-way interactions.

There was a three-way interaction between Status, Prime Type, and Prime Frequency. Figure 44 shows that the type of prime presented impacted the error rate for cognate words depending on the frequency of the prime. Specifically, fewer errors were made when cognate words were preceded by low-frequency translation primes compared to low-frequency unrelated primes (mean error rate = 7.7 % and 13.3 %, respectively). However, the error rate was similar when cognate words were preceded by high-frequency translation and unrelated primes (mean error rate = 10.4 % and 11.0 %). For noncognate words, on the other hand, the error rate was not impacted much by the Prime Type even though it was higher for words preceded by high-frequency rather than low-frequency words (mean error rate range = 18.1 to 20.1% and 9.5 to 11 %, respectively).





*Figure 44.* Experiment 2c Cross-Language E-U masked priming: Mean error rate (%) for the three-way interaction between Status, Priming Type, and Prime Frequency.

There was also a three-way interaction between Status, Target Frequency, and Prime Frequency. Figure 45 shows that when Prime Frequency was low the error rate remained similar for both high-frequency and low-frequency cognates (8.6 and 12.5%, respectively) and high-frequency and low-frequency noncognates (10.3 and 10.2%, respectively). However, when prime frequency was high, fewer errors were made to high-frequency cognates and noncognates (3.5 and 4.7%, respectively) than to low-frequency cognates and noncognates (17.9 and 33.5%, respectively).

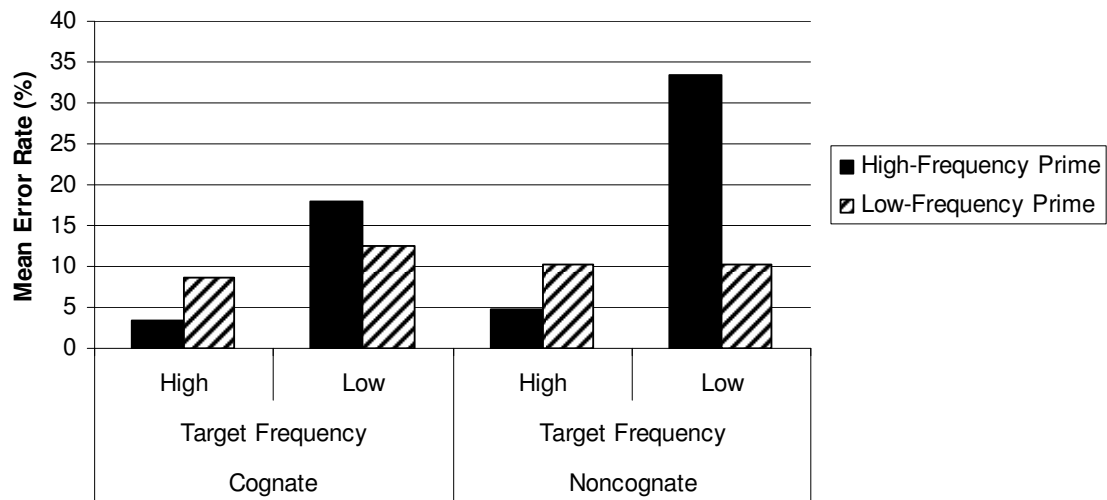


Figure 45. Mean error rate (%) for the three-way interaction between Status, Target Frequency, and Prime Frequency.

There were no other three-way and four-way interactions.

**Planned comparisons.** A series of paired sample t-tests were conducted.

*Frequency-balanced translation pairs.* There was a priming effect for low-frequency cognates with low-frequency primes. In addition, there was a *reverse* priming effect for low-frequency noncognates with low-frequency primes. However, there was no priming effect for high-frequency cognates with high-frequency primes and the same was true for high-frequency noncognates with high-frequency primes.

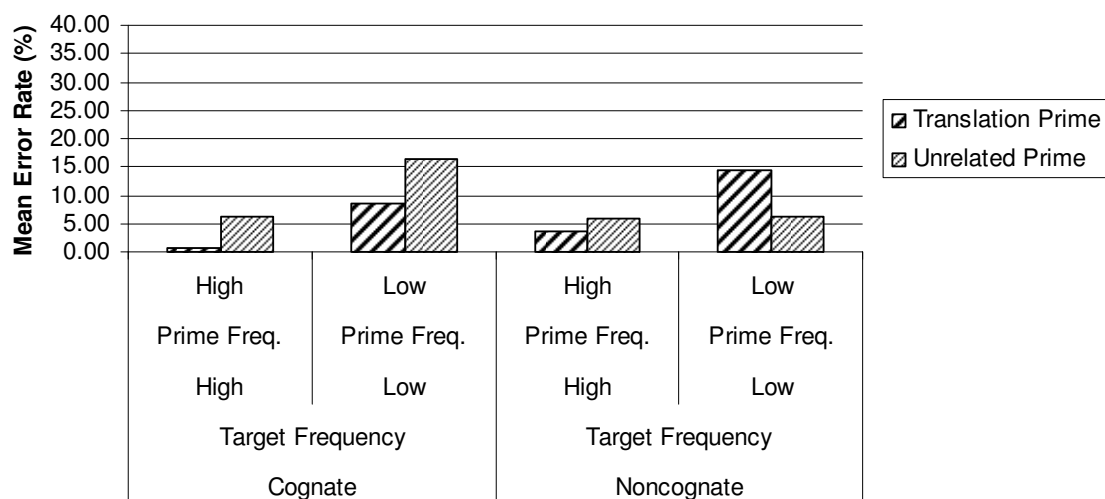


Figure 46. Mean Error Rate for cognates and noncognates in the prime-target frequency balanced conditions.

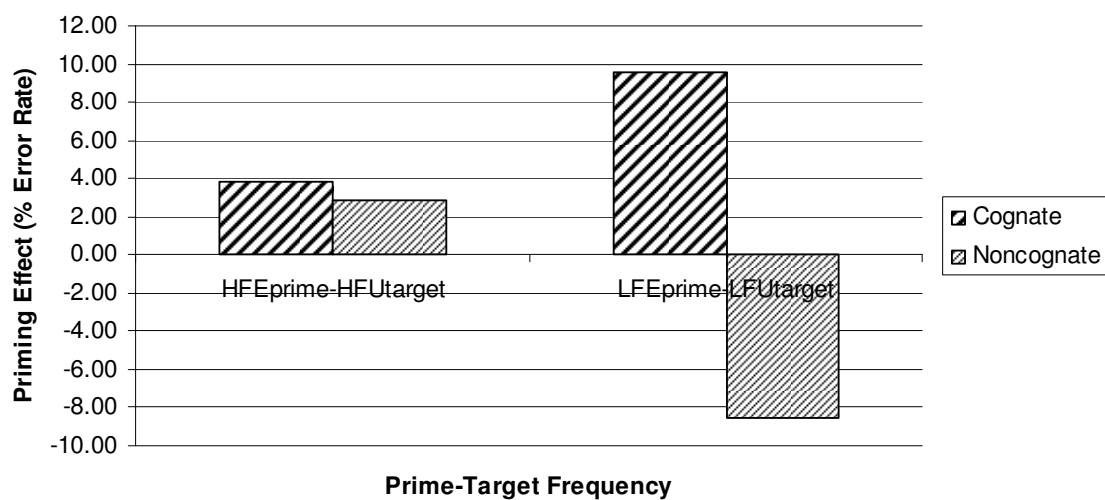
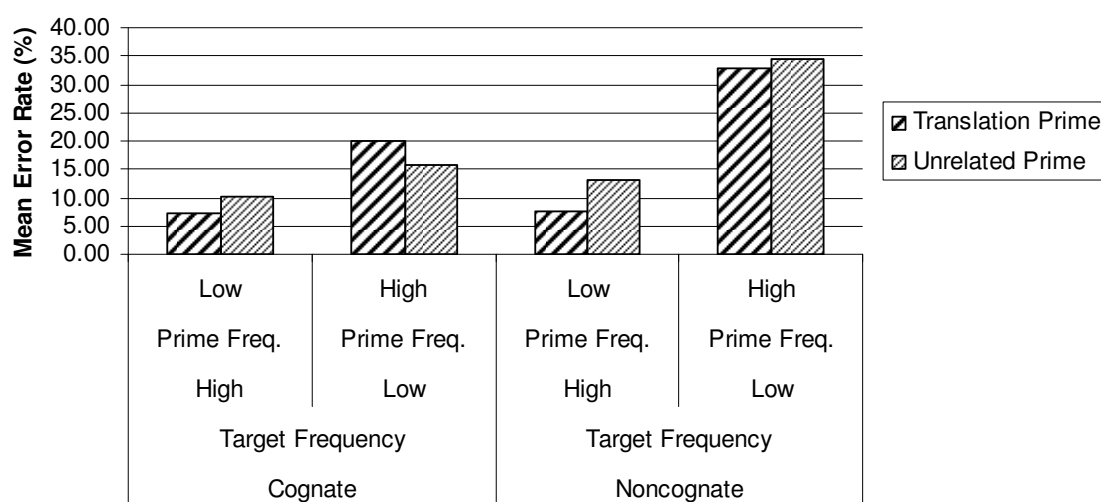


Figure 47. Cross-language priming effect for high-frequency English(HFE) and high-frequency Urdu (HFU), and low-frequency English (LFE) and low-frequency Urdu (LFU) prime-target pairs.

*Frequency-unbalanced translation pairs.* In the frequency unbalanced conditions, there was no priming effect for the high-frequency cognate condition with low-frequency primes. However, the priming effect for high-frequency noncognates with low-frequency primes was approaching significance. There was no priming effect for low-frequency cognates with high-frequency primes and the same was true for the low-frequency noncognate condition with high-frequency primes. Figure 46 shows the mean error rates and Figure 47 shows the priming effect for cognates and noncognates for the frequency-balanced and frequency-unbalanced conditions.



*Figure 46.* Mean Error Rate for cognates and noncognates in the prime-target frequency-unbalanced conditions.

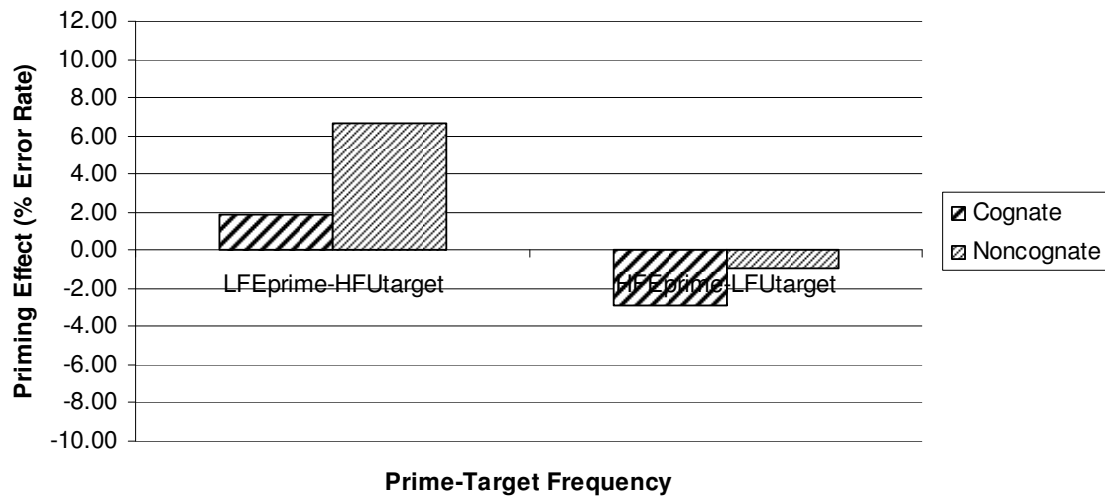


Figure 47. Cross-language priming effect for low-frequency English (LFE) and high-frequency Urdu (HFU), and high-frequency English (HFE) and low-frequency Urdu (LFU) prime-target pairs.

The difference between the priming effect for cognates and noncognates at each of the frequency levels was also examined using a series of t-tests. There was no difference in the priming effect for cognates and noncognates in the high-frequency condition with high-frequency primes,  $t(20) = -0.252$ ,  $p = 0.803$ . There was a difference in the priming effect for cognates and noncognates in the low-frequency condition with low-frequency primes,  $t(20) = -2.939$ ,  $p < 0.05$ . For the frequency unbalanced conditions, there was no difference in the priming effect for cognates and noncognates in the high-frequency condition with low-frequency primes,  $t(20) = 1.156$ ,  $p = 0.261$ . There was no difference in the priming effect between cognates and noncognates in the low-frequency condition with high-frequency primes,  $t(20) = 0.218$ ,  $p = 0.829$ .

## Discussion

The purpose of the within language (E-E) condition was to confirm that these bilingual participants benefited from a 50 ms masked English prime. The results confirm that these bilinguals were sufficiently proficient in English to process and benefit from a 50 ms prime in English.

The goal of the cross-language translation priming condition was to test the hypothesis proposed by Kim and Davis (2003) and Voga and Grainger (2007) that differences in word frequency resulted in the discrepancy in findings by Gollan et al. (1997), Kim and Davis, and Voga and Grainger. While Gollan et al. and Voga and Grainger used lower frequency words, and found a stronger cognate priming effect compared to a noncognate priming effect, Kim and Davis used higher frequency words and found no significant difference in the strength of the priming effect for cognates and noncognates (although the noncognate priming effect was slightly stronger than the cognate priming effect). In these cross-script studies, both a cognate and a noncognate priming effect were obtained. This pattern of results was different from same-script translation priming studies in which only a robust cognate priming effect has been previously reported.

In the current study, the priming effect for cognates (50.85 ms) was larger than the priming effect for noncognates (15.65 ms) in the low-frequency prime-target condition. Voga and Grainger (2007, p. 943) proposed that “translation priming effects reflect the contribution of two separate mechanisms: one sensitive to semantic overlap across prime and target, and the other sensitive to form overlap”. They proposed that cognates may not have any special representation in the lexicon over noncognates, but

rather the additional priming for cognates may simply be due to the additional form priming generated by cognates. Gollan et al. (1997) and Kim and Davis (2003) also proposed that the cognate priming advantage is due to the greater reliance on phonology for low-frequency target words as the unfamiliar orthographic representations are harder to recognize. My results show a trend towards a larger cognate than noncognate priming effect for low-frequency prime-target word pairs and are in line with this proposal. However, unlike the above studies, the priming effect was not statistically significant for both cognates and noncognates. Two possible explanations for this discrepancy are as follows: It is possible that the frequency properties of the words used in the current study influenced the level of priming obtained. While Gollan et al. and Voga and Grainger used lower frequency words than Kim and Davis, the range of word frequency used was quite large. In the current study, the low-frequency prime-target condition used words that had a frequency of up to 11 per million only. Perhaps the low-frequency prime-target words used in the current study do not bring about sufficient activation to cause priming and hence there is no priming effect obtained when strictly low-frequency words are used. However, one problem with this explanation is that a priming effect was obtained for low-frequency primes in the within-language priming condition (DL-DL) and if the primes were strong enough to bring about facilitation in the within-language condition then they should cause sufficient activation in the cross-language condition as well. Alternately, it is possible that the priming effect failed to reach significance due to the large variance in RT across participants. Indeed a priming effect of 50.85 ms is sizable and some authors have even proposed that the maximum size of the masked priming effect is typically in the 50-60 ms range (Gollan et al.). The large variance

across participants may be due to differences in language proficiency or processing strategy used. These points will be taken up in the General Discussion.

In the high-frequency prime-target condition, the priming effect for noncognates (51.51 ms) was higher than that for cognates (-7.98 ms) although this difference was not statistically significant. Kim and Davis (2003) also found a slightly and nonsignificantly larger noncognate priming effect relative to the cognate priming effect (40 ms vs 34 ms, respectively). The larger noncognate effect in the current study was similar to that found by Kim and Davis for high-frequency cognate and noncognate words. However, while Kim and Davis found a significant priming effect for both cognate and noncognate words, this was again not the case in the current study. In fact, in the current study, the cognate condition showed a statistically nonsignificant reverse priming effect. In terms of the priming effect for noncognates, it is possible that the effect failed to reach statistical significance due to the high variance across participants as mentioned earlier. Indeed a priming effect of 51.51 ms is sizable and typically an effect of this size would be statistically significant. The small reverse priming effect for cognates was quite different from the result obtained by Kim and Davis. As previously proposed (in Experiment 2b), it is possible that the trend for noncognate priming may be due to the enhanced semantic priming brought about by the high-frequency translation primes. However, in the cognate condition, the high-frequency prime words seem to be inhibiting the processing of target words. In other words, high-frequency noncognate primes are bringing about facilitation while high-frequency cognate primes are causing inhibition. This point will be further discussed in the General Discussion.



In the frequency-unbalanced condition, where low-frequency target words were primed by high-frequency translations, the noncognate priming effect (101.66 ms) was approaching significance while the cognate priming effect (102.75 ms) was not statistically significant and there was no difference in the priming effect for cognates and noncognates. Again, the high-frequency prime may have resulted in enhanced semantic priming of low-frequency noncognate target words resulting in a noncognate priming effect that was approaching significance. However, in the cognate condition, the high-frequency primes may have brought about inhibition/interference similar to the high-frequency cognate priming condition reported above. This inhibition may have lowered the magnitude of the cognate priming effect, thus preventing a cognate advantage from emerging. Gollan et al. (1997) proposed that enhanced priming for cognates is obtained for unbalanced bilinguals in L1-L2 priming. Unbalanced bilinguals can be likened to frequency-unbalanced cognates (indeed some authors have likened proficiency effects to frequency effects, e.g., Bijeljac-Babic, Biardieu, and Grainger, 1997). As such, there should be a stronger cognate effect for the frequency-unbalanced (high-frequency prime low-frequency target) condition in the L1-L2 priming direction. However, this was not the case in the current study. In fact, a stronger cognate priming effect was found for the low-frequency prime high-frequency target frequency condition in the L1-L2 priming direction as noted below suggesting that an inhibitory process may be at play when high-frequency cognate primes are presented. Interference effects have been reported for higher-frequency prime words previously (e.g., Segui and Grainger, 1990) and this point will be taken up in the General Discussion. In this condition, it is also apparent that the variance in RT across participants is preventing the priming effect from reaching

statistical significance. Both the cognate and noncognate priming effects are of considerable size yet neither of them are statistically significant. This point will also be taken up in the General Discussion.

Following with the above argument, if high-frequency cognate primes are causing inhibition then low-frequency cognate primes should not cause inhibition. Indeed, in the frequency-unbalanced condition, where high-frequency target words were primed by low-frequency translations, there was a cognate priming effect (112.42 ms). However, no priming effect for noncognates (-30.97 ms) was found. As the primes are of low frequency, enhanced semantic priming is not expected in this condition, unlike the previous frequency-unbalanced condition. Hence, the absence of the noncognate priming effect is not unusual. It is not clear, however, why there was a trend towards a reverse priming effect for noncognates. This frequency condition showed the largest cognate priming effect and the only one with a difference between the cognate and noncognate priming effects. The large cognate priming effect for high-frequency target words obtained in this study cannot be explained by increased reliance on phonology as proposed previously for low-frequency target words (e.g., Gollan et al., 1997). This implies that some other mechanism would have to be at play here for this effect to emerge.

Assuming the above explanation, if the low-frequency primes prevent inhibition from occurring and result in a cognate priming effect in the DL-NL priming condition, why is there no cognate priming effect in the NL-DL direction in the same frequency condition in Exp 2b? One possible explanation, as noted earlier, is that in the NL-DL condition the DL (i.e., English) target words were processed too quickly to allow a

cognate priming effect to emerge. In the DL-NL condition, the lower proficiency Urdu targets were still processed slowly enough to allow cognate priming to emerge.

A noncognate priming effect was obtained in the NL-DL direction (Exp. 2b) for high-frequency English words primed by low-frequency Urdu words that was again not obtained in the same frequency condition in the DL-NL priming direction. Earlier, I had explained the noncognate priming effect for this condition by proposing that perhaps the participants had a very high Urdu proficiency so that NL is not effectively NL and so there is strong semantic activation due to the NL prime leading to a noncognate priming effect. The lack of noncognate priming in the DL-NL priming direction for the same frequency condition in the current experiment does not fit with this proposal. The diverging results from the two experiments suggest that the nature of NL-DL priming using frequency-unbalanced prime-translation pairs may be different from DL-NL priming. The exact nature and mechanism is unclear and requires further investigation. Alternately, it is possible that although the participants for the two experiments were drawn from the same participant pool, individual differences in proficiency across participants resulted in the inconsistency across the two experiments.

In the current study there was no interaction between Status, Prime Type, and Target Frequency, and both high-frequency and low-frequency cognates showed a larger priming effect than noncognates. In other words, when prime frequency was not taken into account, there appeared to be greater priming for cognates than for noncognates in both the high- and low-frequency target conditions. However, when prime frequency was taken into consideration the interaction between Status, Prime Type, Target Frequency, and Prime Frequency was approaching significance. The pattern of priming

for cognates and noncognates was different for each of the frequency conditions as described above. These results suggest that frequency differences influence cross-script translation priming for cognates and noncognates. High- and low-frequency balanced cross-script translation pairs have previously not been studied in the same cross-script language pair using masked priming. Furthermore, frequency-unbalanced translation pairs have previously not been studied. These results suggests that it is important to not only pay attention to the frequency range of the prime-target stimuli but also to differentiate between frequency-balanced and frequency-unbalanced translation pairs when conducting translation priming studies upon which models of language access and representation are based.

In summary, there was no priming effect obtained for cognates or noncognates in any of the frequency-balanced conditions unlike the results of the previous three studies. A cognate priming effect was found for the frequency-unbalanced condition in which high-frequency cognates were primed by low-frequency words. A priming effect was found for noncognates that was approaching significance but only when low-frequency targets were primed by high-frequency words. In the current study, the stimuli were more tightly controlled for frequency than in the previous studies. Furthermore, the same Urdu-English bilingual participants were tested on the masked priming task across various frequency conditions.

### **Variance Across Participants**

In this experiment, the overall cross-language priming effect averaged over cognates and noncognates was approaching significance. While there was no interaction between Status and Prime Type in the subject analysis, there was a trend towards a larger

priming effect for cognates compared to noncognates. Furthermore, the interaction between Status and Prime Type was approaching significance in the item analysis. This finding was similar to that found by Gollan et al. (1997) for lower frequency cognate and noncognate words (average frequency 18.05/million). These authors found that for Hebrew-dominant Hebrew-English bilinguals, there was an interaction between cognate status and priming only in the item analysis and not in the subject analysis. They proposed that enhanced priming for cognates over noncognates was only found for a subset of the bilinguals tested and that a robust cognate priming effect was found only for certain types of bilinguals. Furthermore, it is important to note that even though priming is occurring in many of the conditions (at times more than 100 ms) it is not statistically significant. This is unusual in language research and is likely due to the large variance in priming across participants (see Table 27). The high variance in priming across participants in this study may be due to characteristics of the participants such as differences in language proficiency or processing strategy and these points will be discussed below.

Table 27

*The Priming Effect (in milliseconds) Obtained for Each Frequency Condition for Each Participant in Experiment 2c.*

Participant	Target							
	Cognate				Noncognate			
	HFE-HFU	LFE-HFU	HFE-LFU	LFE-LFU	HFE-HFU	LFE-HFU	HFE-LFU	LFE-LFU
1	-204.00	-139.50	-308.42	-370.93	-229.30	93.50	-215.00	235.85
2	152.80	-114.00	10.47	68.15	-474.60	-103.75	233.33	140.80
3	24.35	-503.80	-49.00	303.50	-183.45	-29.65	-173.75	-43.25
4	379.83	5.17	800.50	280.00	85.27	255.67	304.50	296.50
5	129.00	101.80	34.75	304.17	186.00	-30.60	66.00	-53.20
6	455.50	-114.67	612.25	400.50	433.67	302.17	70.66	241.00
7	-263.00	-55.20	-202.10	-65.60	-194.40	32.20	-110.00	44.40
8	-165.20	-143.10	-351.00	108.40	-13.00	188.00	-95.67	-44.00
9	-21.20	-435.17	182.75	-399.75	64.30	631.25	-680.00	-225.90
10	-102.15	-145.25	-287.25	-102.20	-163.45	-224.95	145.00	298.00
11	-271.40	-208.20	12.50	152.60	-301.20	-415.85	-274.00	-144.80
12	-295.25	-124.65	-280.60	-777.40	-56.20	-244.25	34.90	-373.75
13	428.10	-319.17	-105.17	-182.33	94.07	188.00	-280.25	-213.33
14	-201.80	-144.20	-199.80	-172.20	-32.60	63.25	-182.00	-121.53
15	22.60	73.50	-77.10	-10.07	-60.70	181.15	-174.50	399.67
16	-259.90	-198.20	-461.00	-135.85	99.65	-105.75	35.17	-584.35
17	-147.00	117.00	23.50	-525.87	-127.00	-52.85	251.92	54.50
18	122.27	458.00	-553.67	153.00	-129.00	28.60	-445.50	-127.50
19	201.40	99.00	-257.35	-96.80	-91.80	41.20	-144.70	-135.60
20	274.60	-500.47	-461.00	122.00	42.73	-239.00	-300.33	-131.50
21	-92.00	-69.60	-241.00	-121.25	-30.75	92.00	-200.67	159.35

## CHAPTER VI

### General Discussion

The purpose of this study was threefold. First, it was designed to determine if the cognate advantage obtained for same script languages in the simple lexical decision task will also be observed for a cross-script language pair that had previously not been studied (Experiment 1). While a cognate facilitation effect was obtained for low-frequency English cognates with low-frequency Urdu translations, a cognate inhibition effect was obtained for both low- and high-frequency English cognates with high-frequency Urdu translations. The presence of both these cognate effects suggest that lexical access is nonselective for languages with different scripts.

Second, this study was designed to examine whether the difference in findings of Kim and Davis (2003), Gollan et al. (1997), and Voga and Grainger (2007) in terms of the magnitude of the cognate and noncognate priming effect in a masked priming task can be attributed to frequency differences in the word stimuli as proposed by Kim and Davis (2003). Although this study was unable to replicate the findings of the above authors in terms of the magnitude of their priming effect, prime-target frequency indeed emerged as an important variable in the masked priming task (Experiments 2b and 2c).

Third, frequency-unbalanced cross-script translation pairs have previously not been studied in either the simple lexical decision task or the masked priming task. This study was designed to determine how frequency-unbalanced translation pairs are accessed and represented in the bilingual lexicon (Experiments 1, 2b, and 2c). The results suggest that differences in frequencies of cross-language translation pairs have a strong influence on the way these words are accessed and represented in the lexicon.

Importantly, both facilitation and inhibition effects are obtained depending on the frequency properties of the translation pair.

The questions to be examined include the following. First, how may frequency have impacted the pattern of access and priming in the current study? Second, how can these results contribute to the understanding of lexical access and representation of cognates and noncognates in cross-script bilinguals?

### **Word Frequency and Inhibition/Facilitation Effects**

In this study, different patterns of response latencies and priming emerged for various frequency conditions. Similar to previous cross-script masked priming studies both cognate and noncognate priming effects emerged. However, these effects reached statistical significance only for some of the frequency-unbalanced conditions. In addition, priming was obtained in both the DL-NL direction and in the NL-DL direction for the frequency-unbalanced conditions. Furthermore, both facilitation and inhibition effects were evident in the simple lexical decision and masked priming tasks. The inhibition effect has not been reported for cross-script cognates previously in the literature.

To explain the results from this study a model that allows for both facilitation and inhibition effects is required. I will consider the BIA+ model, which is based on the Interaction-Activation model (McClelland & Rumelhard, 1981). Within the IA model, “representations whose activation levels are too close to the most activated candidate may be inhibited in order to reduce their competitiveness and allow one element to be selected” (Segui & Grainger, 1990, p. 68). Previous research with monolinguals has shown an inhibitory priming effect when prime words have a higher frequency than their



targets and the finding that high-frequency words inhibit low frequency targets has been replicated many times (e.g., Grainger & Ferrand, 1994). These results indicate that it is possible to obtain masked inhibitory priming effects for monolinguals and the effect has been explained within the framework of the interactive activation model (McClelland & Rumelhart, 1981) whereby, simultaneously activated word units inhibit the rise in activation of the target word representation. “The prime stimulus serves to preactivate a lexical representation that will continue to receive excitatory input during target word processing (because of orthographic overlap with the target). Since the activation level of lexical representation is also a function of their printed frequency, this model correctly predicts that maximum interference will occur when the prime is a high-frequency word and the target, low frequency” (Bijeljac-Babic, Biardieu, & Grainger, 1997, p. 449).

Davis (2003, as in Davis & Lupker, 2006) simulated masked priming effects in the Interactive-Activation (IA) model of McClelland and Rumelhart (1981) and found that the factor that influenced predicted target latency the most was the frequency relationship between the prime and the target. More specifically, the predicted inhibition effect was directly proportional to the frequency advantage of the prime over the target. Davis and Lupker also examined inhibitory priming in English and found that inhibitory priming effects are stronger for low-frequency target words preceded by high-frequency neighbour primes than for high-frequency target words preceded by low-frequency neighbour primes. In fact, they found that “the larger the prime frequency advantage, the larger the predicted inhibition” (Davis & Lupker, p. 672). These authors also proposed that the IA model successfully explains inhibition masked priming data.

In a study by Segui and Grainger (1990), French monolinguals were tested and a 48-ms inhibition effect was obtained when high-frequency orthographic neighbours primed low-frequency target words. The authors also found a nonsignificant (10 ms) facilitation effect when low-frequency neighbours primed high-frequency targets. These results were believed to support the prediction of the interactive activation framework. The authors proposed that “the prior presentation of masked primes could have served to enhance the competitiveness of the prime's representation during target recognition. So, if the prime is of higher frequency, it will increase the inhibitory capacity of this higher frequency neighbor and lengthen target identification times. If, on the other hand, the prime is a lower frequency neighbor of the target, then even preactivation of its representation through prime presentation is not sufficient for its activation level to rise enough to produce any noticeable inhibition of the target, as the target representation itself receives some preactivation from the prime” (Segui & Grainger, p. 69). In another experiment, the authors tested Dutch monolinguals and when medium-frequency words (192 occurrences per million) were primed by high-frequency neighbours (874 occurrences per million) a 41 ms inhibition effect was obtained, whereas when medium-frequency words were primed by low-frequency neighbour primes (9 occurrences per million), a nonsignificant (12 ms) inhibition effect was obtained. They concluded that the pattern of priming effects was dependent on the relative prime-target frequency and not the absolute target frequency.

Two bilingual studies have also reported inhibition effects for same-script frequency-unbalanced pairs. Bijeljac-Babic, Biardieu, and Grainger (1997) studied masked orthographic priming in French-English bilinguals to examine if a similar

inhibition would be obtained across languages. In their first experiment, the targets were low-frequency English words (i.e., mean frequency 24 per million) and the primes were high-frequency English or French words (i.e., mean frequency 266 and 388 per million, respectively). They found an inhibitory effect for orthographically related primes (e.g., help-HELM) relative to orthographically unrelated primes (e.g., rich-HELM) when prime and target were from the same language. This finding suggests that any facilitation effects due to orthographic form priming were eliminated due to inhibition effects from lexical competition (Dijkstra & Van Heuven, 2002). Additionally, the inhibitory effect was also found for orthographically related primes (e.g., joie-JOIN) relative to orthographically unrelated primes (e.g., acte-JOIN) when prime and target were from different languages. This finding suggests that “lexical knowledge from the other language affected target recognition, which provides evidence supporting language non-selective access to the bilingual lexicon” (Dijkstra & Van Heuven, p. 179). In their second experiment, the targets were low-frequency French words (i.e., mean frequency 42 occurrences per million) and the primes were high-frequency French or English words (i.e., mean frequency 388 and 266 per million, respectively). They found a similar pattern of results as in the first experiment. Furthermore, the impact of second language proficiency of the bilingual participants on between-language orthographic priming was examined using participants who were either proficient bilinguals, beginning bilinguals, or French monolinguals. For proficient bilinguals, a within language inhibitory priming effect and an even larger cross language inhibitory priming effect was obtained. For beginning bilinguals, however, the magnitude of the priming effect was smaller, and the effect altogether disappeared for the monolingual group. They concluded that

proficiency in the nondominant language has an analogous effect to word frequency and that higher language proficiency results in stronger inhibition. These findings supported the proposal that whole-word orthographic representations in both the languages of the bilingual are simultaneously activated (i.e., nonselective access) indicating interconnectivity of the bilingual lexicon at the word level.

Bijeljac-Babic, Biardieu, and Grainger's (1997) finding of inhibition when high-frequency orthographic primes are followed by low-frequency targets was explained in terms of the IA model and the authors proposed that the more a given unit is activated the more it inhibits other units, and "the inhibitory effects of masked orthographic priming are therefore the result of the prime word's representation reaching a relatively high activation level during processing of the target and thus inhibiting the rise in activation of the target word" (Jacobs & Grainger, as in Bijeljac-Babic, Biardieu, & Grainger, p. 450).

More recently, Dijkstra, Hilberink-Schulpen, and Van Heuven (2010b) also reported inhibition effects in a Dutch-English masked priming study. The between language (L2-L1) inhibitory priming effect in this study, however, was smaller than in the previous study (21 ms vs. 43 ms) and was nonsignificant. The authors proposed that this may be either due to proficiency differences between the bilinguals tested in the two studies or due to participants placing greater focus on accuracy as compared to speed. The inhibition effect was understood by these authors in terms of lexical level (word level) competition. They proposed that facilitation at the sublexical level and inhibition at the lexical level may be leading to an overall statistically nonsignificant inhibition effect.

In previous research with same-script translation pairs, inhibition effects have been explained in terms of orthographic overlap. In the current study, however, there is no word level competition at the orthographic level, yet inhibition effects are still observed. As noted earlier, previous cross-script language studies have not reported inhibition effects. The results from the current study suggest a trend towards masked inhibitory priming even for cross-script languages where there is no orthographic form similarity. These results therefore suggest that phonological form similarity may be leading to the inhibition priming effect, or in other words, the locus of the inhibition effect may be at the phonological level. The assumption of lateral inhibition and facilitation effects due to phonological form overlap is consistent with the view that bilinguals have an integrated lexicon across languages and lexical access is nonselective.

Indeed, both orthographic and phonological information is believed to play a fundamental role in visual word recognition (Van Orden, 1987; Ferrand & Grainger, 1994). It is believed that phonological information is automatically and rapidly encoded during monolingual visual word recognition (Grainger & Ferrand, 1994). In the bilingual domain a number of studies have found evidence for language nonselective access with respect to orthographic, phonological, and semantic codes (e.g., Dijkstra, Grainger & Van Heuven, 1999; Jared & Kroll, 2001; as in Dijkstra & Van Heuven, 2002) and indeed the BIA+ model recognizes that bilingual word recognition is affected by cross-linguistic phonological and semantic overlap, in addition to orthographic overlap (Dijkstra & Van Heuven). However, while this model can successfully account for effects obtained with same-script nonidentical cognates (e.g., Font, 2001), it proposes that studies conducted with cross-script language pairs will provide evidence in support of language specific

access while acknowledging that phonological similarity effects might still occur (Dijkstra & Van Heuven). Let us consider how activation of phonological codes occurs within the BIA+ model.

### **Activation of Phonological and Semantic Codes**

According to the BIA+ model (Dijkstra & Van Heuven, 2002) activation of lexical orthographic candidates proceeds in parallel based on their similarity to the input string as well as on the resting level of activation of individual items, which is influenced by a number of factors such as word frequency and L2 proficiency. When orthographic representations at the sublexical and lexical levels become active, they subsequently activate associated phonological and semantic representations. Thus, there is a slight delay between the activation of orthographic representations and associated phonological and semantic representations of both the languages. In addition, as L2 representations are assumed to have a lower subjective frequency, this explanation implies that the activation of L2 phonological and semantic representations will lag behind the activation of L1 phonological and semantic codes. This is called the “temporal delay assumption”. Consequences of this assumption include the following: (1) larger cross-language effects in the L1-L2 direction than in the opposite direction; (2) an absence of cross-language phonological and semantic effects for certain words if task demands do not allow slower codes (e.g., L2 phonological or semantic codes) to affect response times. Indeed, task demands have been suggested to impact cross-language effects in a number of studies (e.g., Dijkstra et al., 1999; Lemhofer & Dijkstra, 2004).

While Dijkstra and Van Heuven (2002) provide a detailed account of how interlingual homographs may be activated and represented, they note that there is

insufficient data with respect to the relationship between orthographic, phonological, and semantic codes of cognates in order to implement these in the BIA+ model. Simple lexical decision task studies by Dijkstra et al. (1999) and Lemhofer and Dijkstra (2004) resulted in conflicting findings for the role of phonological overlap (i.e., inhibition vs. no effect, respectively) and it was suggested that the role of phonology required further investigation. Furthermore, in these same-script Dutch-English bilingual studies, there was an absence of facilitation for the SP (semantic and phonological overlap) cognate condition and this was in contrast to cross-script bilingual masked priming studies (e.g., Gollan et al., 1997; Kim & Davis, 1993; Voga & Grainger, 2007) where facilitation effects for cognates were obtained. In the current study, both facilitation and inhibition effects were suggested with respect to cross-script cognates in both the simple lexical decision and masked priming tasks thereby complicating the picture even further.

Let us consider Voga and Grainger's (2007) viewpoint on cross-script cognate representation. According to Voga and Grainger, cognates do not have a special representation in the bilingual lexicon. They suggest that cognate and noncognate *facilitation* is produced by their shared meaning representation and the cognate advantage over noncognates is due to the form-priming component in addition to the semantic-priming component. Voga and Grainger used the BIA+ framework to explain the cognate-priming advantage over noncognate-priming. They proposed that for cross-script cognates orthographic representations across languages do not compete and are therefore not directly coactivated by the printed word. They proposed that activation of the orthographic representation of a prime word's translation equivalent is dependent on both the "bottom-up (shared form) and top-down (shared meaning) facilitation" along

with lateral inhibition within-level. As cross-script cognates do not suffer from lateral inhibition, their facilitation is maximal, followed by that for cross-script noncognates. They also proposed that the lack of enhanced cognate and noncognate priming for the L2-L1 priming direction is due to insufficient phonological activation from L2 primes.

Voga and Grainger's (2007) proposed mechanism for cognate and noncognate priming in cross-script translation pairs does not allow for inhibition effects or reverse priming to emerge. Their conceptualization of cross-script cognate and noncognate priming within the BIA+ model is based on bottom-up (shared phonological form) and top-down (shared meaning) facilitation. The results from the current study, specifically the trend for inhibition in certain frequency conditions, cannot be explained within the framework proposed by these authors.

How can inhibition be explained with respect to cross-script cognates with high-frequency translations? An attempt at a tentative explanation is offered here. Grainger and Ferrand (1994) proposed (within the context of the IA model) that a positive lexical decision response will be triggered once a critical activation level is reached by either the orthographic or the phonological lexical representation. This tends to be the orthographic representation when the stimulus is a written word, as there is a lag involved between orthographic and phonological activation. However, in the case of masked priming with a higher-frequency orthographic neighbour there will be strong within-level inhibition at the level of orthography but not at the phonological level if the prime and target are homophonic and share the same phonological representation (e.g., rain-REIN). In this case the phonological representation reaches threshold first, leading to facilitation.



In the current study, the cross-script cognates had no orthographic overlap and while they overlapped in phonology, this overlap was not always complete (e.g., *captain*-*كپتان*/kup-tän). Applying the above argument to the case of phonology, for high-frequency cross-script primes when phonological overlap is incomplete, there may be inhibition at the phonological level. When a high-frequency prime is presented, it will activate its phonological representation. As cross-script cognates with incomplete phonological overlap may not share the same phonological representation, there may be within-level inhibition at the level of phonology. Thus, it will take longer for the phonological representation to reach threshold giving rise to inhibition. Libben and Titone (2009) have also made the case for a reduction in cognate facilitation when there is phonological discrepancy within cross-language cognates based on their work with sentences. Overall, this explanation implies nonselective access and interconnectivity of the lexicon.

More recently, Dijkstra et al. (2010a) elaborated on the access and representation of cognates within the BIA+ model and allowed for a single representation for identical cognates but two separate representations for nonidentical cognates. They propose that the activation of two representations would give rise to accompanying lateral inhibition between nonidentical cognates and would lead to an increase in RT latencies relative to identical cognates. However, any further decrease in similarity between cognates and their translations would not bring about substantially greater inhibition as “the number of activated representations remains the same”. Indeed, these authors found this to be the case for Dutch-English bilinguals tested on a lexical decision task. Applying this argument to the current cross-script study, the RT latencies for phonologically identical

cognates would be the shortest while for phonologically nonidentical cognates RT latencies would be longer due to accompanying lateral inhibition at the phonological level. Dijkstra et al. (2010a) also proposed that while lateral inhibition would be absent for matching lexical-phonological representations, it would be very strong when phonological representations in the two languages are very similar. Furthermore, Dijkstra et al. (2010a) noted that the inhibition effects were dependent on word frequency, which is in line with the findings from the current study.

Lam and Dijkstra (2010) propose the need to not only “integrate semantic and phonological representations into the BIA framework” but also to simulate these mappings. The simulation of orthographic-phonological mappings is believed to be a challenging task due to the “position-specific letter coding” characteristic of the IA model, whereby the spread of activation to a letter position beyond the position in question is prohibited (e.g., the model does not allow CLAM to be mistakenly recognized as CALM even though such errors are not unusual in human word recognition). Lam and Dijkstra propose that this may point to the need to include sublexical units within the BIA framework that are not letters (e.g., syllables). One way to explain the masked inhibition priming in cross-script languages would require the assumption that orthographic information is represented in the form of abstract codes. Indeed, it has been proposed that in order to truly incorporate phonological and semantic representations within bilingual models, there might be a need to develop “completely new localist or connectionist models for bilingual word retrieval” (Lam and Dijkstra, p. 502).

### **Issues Arising: Variance across participants**

While the current study set out to examine script- and frequency-effects, other issues arose and require further comment. Specifically, a large variance across participants in terms of priming effects was evident (see Table 11) and this may have resulted in statistically nonsignificant findings even when the actual size of the priming effect was quite large, at times exceeding 100 ms. Two possible explanations for this variance were proposed earlier, i.e., differences in language proficiency across participants and differences in the processing strategy adopted by various participants to complete the same task. I will now examine these possibilities further.

**Language Proficiency and Individual Differences.** Language proficiency is certainly believed to be an important variable in visual word recognition studies. For example, Gollan et. al. (1997) explained the priming asymmetry (i.e., priming in the L1-L2 direction and the lack of priming in the L2-L1 direction) by proposing that marked differences in language proficiency prevent the L2 prime from being processed in a timely manner to impact L1 target processing. In other words, L1 target processing “overtakes” L2 prime processing thereby preventing a priming effect from emerging. They predicted that priming from L2 to L1 should emerge if processing speed differences between L2 and L1 are reduced. As such, priming effects are more likely to emerge for more balanced bilinguals than for less balanced bilinguals. This was certainly the case in Gollan et. al.’s study where a priming effect emerged in the L2-L1 direction for more balanced bilinguals but not for less balanced bilinguals. Differences in the size of the inhibitory priming effect for proficient bilinguals and beginning bilinguals have also been previously noted (Bijeljac-Babic, Biardieu, & Grainger, 1997).

In order to examine whether language proficiency impacted RTs in the current study, a series of correlations were run for each of the experiments. A value for language proficiency was obtained for each participant by subtracting the number of errors made on the English or Urdu paragraph reading task from the number of words read per minute on the same task. Language proficiency correlated strongly with RT across all experiments (see Appendix E for the results from this analysis). Therefore, an Analysis of covariance (ANCOVA) was conducted for each of the experiments (see Appendix E for the ANCOVA statistics) using English and/or Urdu language proficiency as covariates depending on the language of the task. For example, in Experiment 2b, English proficiency was used as a covariate in the E-E within language priming task, while Urdu proficiency was used as a covariate in the U-U within language priming task. For the U-E cross language priming task, both English and Urdu were used as covariates.

The between-subjects effect(s) for the covariate(s) was not significant for the experiments in which a sizable but statistically non-significant facilitation/inhibition (i.e., Experiment 1 Urdu target words) or priming effect (i.e., Experiment 2b U-E cross language priming and Experiment 2c E-U cross language priming) were noted. Thus, any adjustments made by the covariates are not statistically reliable in the ANCOVA. However, even though individual differences in participants' language proficiency, as defined by their paragraph reading ability, cannot account for the large variance in RT, the language proficiency explanation cannot be completely ruled out.

For the current study, the average reading proficiency for the participants as indicated by the number of words read within a specified period of time (as in Experiments 1, 2a, 2b, and 2c) and the number of errors made (as in Experiments 1 and

2c), was higher for English than for Urdu, and this was also true for self-reported language proficiency averaged across the domains of speaking, comprehension, reading, and writing (as in Experiments 1, 2b, and 2c). However, an examination of self-reported proficiency in the two languages for individual participants revealed differences in reading, comprehension, speaking, and writing proficiency. In addition, it was noted that when self-reported language proficiency was averaged across these domains for individual participants, most participants reported stronger English proficiency, but a few reported stronger Urdu proficiency while others reported equal proficiency in English and Urdu.

Titone et al. (2011) note that the degree of participant bilingualism is a key difference not only across studies but also within a particular study given the variability in language knowledge and usage patterns among bilinguals. Both the age of acquisition of the L2 as well as current L2 exposure have been noted to impact lexical activation when processing L1 and L2 words (Titone et al.; Whitford & Titone, 2012). It is important here to reiterate an earlier point about socioeconomic/cultural factors that may have been at play. While all the participants were students at the same post-secondary institute, socioeconomic backgrounds varied considerably and consequently the nature of their bilingualism likely also varied. For example, language proficiency may vary considerably across different modalities and this may be impacting the results from the current study (see Fraga, Tejjido, & Alameda, 2002 for a similar explanation). Even though Urdu is spoken daily in conversation by all the participants, many do not read Urdu regularly. Furthermore, while secondary and post-secondary educational textbooks are in English, both Urdu and English may be spoken within the classroom. Further

complicating this picture is the manner in which the participants acquired their languages as children. Participants reported a range of language acquisition experiences in terms of when their languages were acquired, the combination of languages spoken with family members and friends (i.e., Urdu only, Urdu more than English, English and Urdu equally, English more than Urdu, and only English), as well as in terms of education (e.g., language of instruction through elementary, middle, high, and post-secondary education). It is also interesting to note that when asked which language they considered to be their “first language” some participants identified it to be English, others considered it to be Urdu, and a few were uncertain about how to respond to this question. As such, while these native Urdu speakers may be considered to be English-dominant, or balanced in competence across the two languages, they may be Urdu dominant in speech but English dominant in reading and writing or some other combination of language dominance across different modalities. Indeed, Fraga et al. noted that bilinguals may be balanced in competence across languages but not in use and that this may impact results from studies with bilinguals. The data from their study with Galician-Spanish bilinguals suggested that their bilingual participants were balanced in competence across the two languages but non-balanced in use such that Galician was their dominant language in speech while Spanish was the dominant language in reading. They used this discrepancy in competence and use across linguistic modalities to explain why their bilingual participants responded differently to low-frequency cognates from the two languages and this led them to propose a need for longitudinal studies and a developmental model of bilingual lexical memory.

Indeed, the role of individual differences in language proficiency is emerging as an important one in bilingual research. There is increasing recognition that the bilingual lexicon “arises under specific contexts of acquisition and use” (Green, 2002) and a number of researchers in the field have called for an account of individual differences between bilinguals within models such as the BIA+ (e.g., Green; Van Hell, 2002). These individual differences may lead to variations in the amount of resting level activation of representations in the word identification system or within parameters involved in the task/decision mechanism (Dijkstra & Van Heuven, 2002; Van Hell). A related idea is how second language acquisition and learning over time needs to be incorporated within the BIA+ (Li, 2002; Thomas, 2002) because from a developmental perspective, both language specific and language nonselective access is possible depending on language proficiency levels (Li, 2002). A computational model focusing on how the learning history of a bilingual individual impacts the emergence and development, as well as the interaction between representational structures of the bilingual lexicon has been proposed and demonstrates that the age-of-acquisition of L2 impacts between-language competition for bilingual representations (Li, 2009; Zhao & Li, 2010). Li (2002) proposes that the study of bilingual language representation “should ultimately be connected to research in developmental bilingualism”. Language use is a complex behaviour and bilingualism lies on a continuum thereby creating the need for models that are non-dichotomous and dynamic in nature (Li, 2002; Thomas).

It is important to note here that controlling for language proficiency is not an easy task in the case of English-Urdu participants given the unique language backgrounds that individuals have in the context of the diverse socioeconomic, ethnic, and educational

background in a mega city such as Karachi, where this study was conducted. Thus, it is possible that differences across participants in terms of how the two languages were acquired, how they are maintained, and in terms of the role that modality specific proficiency levels (i.e., spoken, written, reading comprehension, auditory comprehension, and production) play, may be complicating the resulting picture in the current study. One way to study the impact of modality specific proficiency levels on lexical access would be to use an auditory lexical decision task in addition to a visual lexical decision task to tease out the impact of verbal and reading proficiency amongst bilinguals. This is a possible avenue for future investigation.

**Processing Strategy.** Dijkstra and Van Heuven (2002) suggested that when participants from the same population are tested using the same stimulus material the differences in results across experiments are due to nonlinguistic factors such as task demands or participant expectancies rather than from changes in the relative activation levels of cross-language items. One possible explanation for the large variance across participants within the same experiment is that participant strategy varied widely and the presented task was approached differently by different participants. Indeed, a closer examination of the priming data for each of the frequency conditions in Experiment 2c shows that large priming effects were evident in both the positive and negative directions for various participants for the same frequency condition. This raises the question of why participants may be adopting different processing strategies and one possibility is that the task instructions were understood differently by various participants. It is possible that some participants were incorrectly trying to determine if the presented words in Experiments 2b and 2c were *originally* part of the English or Urdu languages respectively



(i.e., before being adopted into the other language as “loan words” as described by Gollan et al., 1997). If this were the case, then some of the participants would be performing the actual task (i.e., lexical decision) whereas other may be performing a variant of the language decision task while others still may be performing a combination of the two tasks over the course of the experiment. This difference in processing strategy may have resulted in a combination of facilitation and inhibition effects within and across participants.

Indeed, task demands, participant expectations, and the response strategy adopted by participants have been reported as being important variables in word recognition (e.g., Dijkstra et al., 1999; Lemhofer & Dijkstra, 2004) and both facilitation and inhibition effects have been reported due to varying task demands and processing strategies. For example, Van Heuven, Dijkstra, and Grainger (as cited in Dijkstra & Van Heuven, 2002) used a progressive demasking technique to show that both facilitation and inhibition effects could be obtained within the same study for high-proficiency participants who changed their response strategy across the four blocks of the experiment. Dijkstra, Timmermans, and Schriefers (2000) used a go/no go experimental paradigm to test Dutch-English bilinguals on a mixed list of interlingual homographs and either Dutch or English control words. They were required to respond only if the presented word was Dutch (Dutch go/no go) or English (English go/no go) but not if a word of the nontarget language (i.e., English or Dutch, respectively) was presented. These authors reported inhibition effects for homographs particularly when the frequency of the interlingual homograph in the nontarget language was high.

Dijkstra et al. (2010a) propose that similar to interlingual homograph effects, cognate effects may also be task dependent. For example, in the study by Font (2001), while a facilitation effect was seen for French-Spanish neighbour cognates in a lexical decision task, an inhibition effect was seen for neighbour cognates in a language decision task. A similar finding was reported by Dijkstra et al. for Dutch-English cognates. They found that in the language decision task cross-language orthographic similarity led to inhibition effects on RTs, whereas in the lexical decision task cross-language orthographic similarity had led to facilitation effects on RTs. In their language decision task, when the target word was English and was not an identical cognate, Dutch frequency influenced RTs. In addition, for identical cognates, the higher the Dutch frequency was, the slower the RTs to English targets. These results led the authors to propose a “Dutch-or-no-Dutch” mechanism whereby participants were rejecting a word as a Dutch word based on scanning of the visual input for divergences from Dutch orthographic patterns without English phonological or lexical representations. The authors reported fierce competition for identical cognates in the language decision task.

Kim and Davis (2003) explained the different results across various tasks in their study within the context of the BIA+ model which has a task/decision system interconnected with but partially independent of the identification system (see Dijkstra & Van Heuven, 2002 for a detailed account of this mechanism). Within this model, the candidates from both languages are always activated but participants “may adapt their decision criteria to optimize their performance” (Dijkstra & Van Heuven). Thus, in performing a task (such as lexical decision) an early preconscious, automatic level of processing may be followed by an attention-sensitive level in which percepts are selected

with reference to contextual factors of various sorts and linked to particular responses relevant to the task at hand” (Dijkstra & Van Heuven, p. 191).

Within the BIA+ model the task/decision mechanism “specifies how activated and selected representations in the identification system are bound to possible responses” (Dijkstra & Van Heuven, 2002). For example, in the lexical decision task, sufficient lexical activation at a given moment in time will lead to a “yes” response while a “no” response will be given if the lexical activation is low or a mismatch is noted at some critical moment in time. Information from different sources may be used in parallel by the schema to complete the task, although the model at present suggests that orthographic representations play a major role. In the generalized lexical decision task, a “yes” response is required to an input word in any of the two languages of the bilingual requiring a more complex decision mechanism. In language decision, the responses “are assumed to be bound to language tag representations, connected to language specific form representations or lemmas” (Dijkstra & Van Heuven). The authors proposed that the “dynamic adaptation of stimulus response bindings and decision criteria may help to explain some remarkable lexical decision results in the literature” (Dijkstra & Van Heuven) such as unusual findings like null results for interlingual homographs in English lexical decision studies (e.g., Dijkstra et al., 1998b, as in Dijkstra & Van Heuven). They proposed that in a lexical decision task bilingual participants following the task instructions set up a task schema such that a “yes” response is bound strongly to all English words using a language tag, while the “no” response is bound to other language words and nonwords. When an interlingual homograph is presented there will be no strong response competition as long as the Dutch reading of the homograph is not

strongly bound to the “no” response despite activation of both readings of the homograph. Thus, no RT differences will be noted between homographs and control words. However, when Dutch words are introduced in the list, they will be bound to the “no” response more strongly leading to stronger response competition and inhibition effects for interlingual homographs. The authors proposed that both intra-level effects (e.g., those explaining word frequency effects) and extra-level effects at the task/decision mechanism (e.g., those explaining differences between tasks) are at play during the execution of the lexical decision task. It is possible that the combination of facilitation and inhibition effects within the current study for different participants is due to a combination of intra-level and extra-level effects based on participants’ understanding of the task and the approach taken by them to complete the task.

### **Conclusion**

This study lends further support to the body of evidence for nonselective lexical access and interconnectivity of the bilingual mental lexicon using a previously unstudied cross-script language pair. Both frequency-balanced and frequency-unbalanced translation pairs were used within the same tasks in order to address discrepancies in the literature that have been attributed to frequency differences across studies. Both facilitation and inhibition effects were found for cross-language translation pairs in the simple lexical decision task and masked priming task depending on their frequency properties. Specifically, high-frequency translations of cognate words appeared to bring about inhibition. The inhibition effect has not been reported for cross-script cognates previously in the literature and as Urdu-English translations pairs do not share a common script, this inhibition effect is proposed to occur at the phonological level. The current

version of the BIA+ model does not incorporate lateral inhibition effects at the phonological level for cross-script cognates. The findings from this study are explained within the BIA+ framework by allowing for lateral inhibition at the phonological level. Arising issues included individual differences in language proficiency due to diverse language histories, particularly modality-specific proficiency, and individual differences in processing strategy. These are important to consider in future work with bilinguals.

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## Appendix A

### Experimental Stimuli

#### Experiment 1: Frequency-Balanced Urdu-English Cognate and Noncognate Words

Frequency	Cognates		Noncognates	
	Urdu	English	Urdu	English
HFU-HFE	کالج	COLLEGE	آنکھ	EYE
	ڈگری	DEGREE	ہاتھ	HAND
	ڈاکٹر	DOCTOR	برف	ICE
	فلم	FILM	دودھ	MILK
	گلاس	GLASS	چاند	MOON
	نام	NAME	ناک	NOSE
	نمبر	NUMBER	تیل	OIL
	فون	PHONE	کاغذ	PAPER
	اسکول	SCHOOL	دریا	RIVER
	سائنس	SCIENCE	کھڑکی	WINDOW
LFU-LFE	کارٹون	CARTOON	کیکڑا	CRAB
	کیسٹ	CASSETTE	گدھا	DONKEY
	چیتا	CHEETAH	باجرا	MILLET
	چٹنی	CHUTNEY	کشمش	RAISIN
	سرکس	CIRCUS	جھینگا	SHRIMP
	گٹر	GUTTER	گلہری	SQUIRREL
	لوشن	LOTION	درزی	TAILOR
	پوسٹر	POSTER	ران	THIGH
	سلاد	SALAD	کانٹا	THORN
	شیمپو	SHAMPOO	بٹوا	WALLET

### Experiment 1: Frequency-Unbalanced Urdu-English Cognate and Noncognate Words

Frequency	Cognates		Noncognates	
	Urdu	English	Urdu	English
HFU-LFE	بازار	BAZAAR	بادام	ALMOND
	چائے	CHAI	لونگ	CLOVE
	گرام	GRAM	کھانسی	COUGH
	میٹر	METER	لہسن	GARLIC
	مسلم	MUSLIM	ادرک	GINGER
	نواب	NAWAB	دال	LENTIL
	پنجاب	PUNJAB	کنول	LOTUS
	راجہ	RAJAH	طوطا	PARROT
	شاہ	SHAH	بلغم	PHLEGM
	وزیر	VIZIER	پالک	SPINACH
LFU-HFE	کپتان	CAPTAIN	کلیسا	CHURCH
	فائل	FILE	قہوہ	COFFEE
	لیڈر	LEADER	صلیب	CROSS
	میجر	MAJOR	انجیر	FIG
	مارکٹ	MARKET	دل	HEART
	مادر	MOTHER	دوزخ	HELL
	پارک	PARK	خضم	HUSBAND
	اسکیل	SCALE	چابی	KEY
	ٹائم	TIME	نشست	SEAT
	ٹرین	TRAIN	آرزو	WISH

## Experiment 1: Nonwords

Nonwords		Nonwords		Nonwords	
Urdu	English	Urdu	English	Urdu	English
دپتر	POSTWAG	تاغی	LEH	گاموشی	MILLDIM
خرشہ	ADJURT	فجاد	SEAG	رشمٹ	LARTSPUR
ٹکوان	LEGITE	باش	BHE	حسام	ARNINGS
خوغ	MURN	رالو	WANY	باکم	KRUMLIN
مجرش	TURSE	چلمڑ	SHAP	جمار	PIPPON
دشغ	DAFE	دشد	RIBE	غال	TIGGLE
فاشوق	CORDER	برغ	CEC	تانپ	DARTLY
لاغ	MOTEC	دفوت	TAGED	خنڈلی	HESTED
تپارت	VERNOD	چملہ	PARNS	منجر	VAPEL
خبانہ	DRANCHY	ساران	KENMAN	درخار	DOSPOND
روطال	BUTTENG	سکاوٹ	SIPHUN	سگارہ	SOUND
تامن	BUBS	تشمین	KUSTER	جشتہ	GUNMED
سوام	GUMBLE	بندق	SPEAT	خعاون	BINKER
صاقن	PODDY	پرپال	HIG	دھوت	MILISH
گوفان	LEXING	لس	SHAUT	باگندہ	BOCKLE
فورج	TROPEL	خراٹ	HEES	پمندر	RESONOUS
پسری	CUST	حمن	POSTMEL	سام	WHALEY
کدفین	TRUMS	پغلی	ANP	حمر	TWITH
ٹربی	NUCK	طوما	CAYS	رخمار	ITEAL
چغمہ	BRACK	بادو	FONG	لوتی	ROUKED
پارود	PENACE	باڈاٹ	EXHIME	دپاغ	EPIUM
چکرہ	SLOH	سماش	FRAWL	خلدان	TISTRO
قواج	HILD	غاک	VEXTON	خشبر	FUTTER
شگاب	CODOS	سالج	WICKEH	خبف	HILK
بارت	DISMAB	تخلو	PEETED	چراس	TAMPIN
غودا	DENTEV	حست	LOGIDS	خوات	CUPIES
چڑوس	MULAISE	خترہ	ENKS		



**Experiment 2a and 2b: High-Frequency and Low-Frequency Urdu Target, Identity Prime, and Control Words for the Within-Language Priming Task.**

Frequency	Control	Identity Prime	Target
HFU-HFU			
	رنگ	کار	کار
	ڈھیر	کارڈ	کارڈ
	مرغ	کوٹ	کوٹ
	حکومت	کمپنی	کمپنی
	شام	گیس	گیس
	کسان	مشین	مشین
	مہم	منٹ	منٹ
	مزدور	پولیس	پولیس
	بیماری	پروفیسر	پروفیسر
	پیغام	رپورٹ	رپورٹ
	شکل	جسم	جسم
	ادب	شہر	شہر
	راز	پہل	پہل
	منظر	مکان	مکان
	تشہیر	انسان	انسان
	بھوک	جھیل	جھیل
	درد	رات	رات
	سالن	موسم	موسم
	باپ	جلد	جلد
	طاقت	عورت	عورت
LFU-LFU			
	خودکشی	بینڈیج	بینڈیج
	قالین	بلاوز	بلاوز
	لسی	بگل	بگل
	قندیل	لپسٹک	لپسٹک
	گلدان	مارکر	مارکر
	ملال	پیڈل	پیڈل
	محفل	پکنک	پکنک
	گودی	پولو	پولو
	جھولا	سوئٹر	سوئٹر
	کوکھ	ٹائر	ٹائر
	رکھیل	چھالہ	چھالہ

دانشور	گلدسته	گلدسته
ملاح	رشوت	رشوت
شیشم	تالی	تالی
موتیا	ناریل	ناریل
چغلی	مجرم	مجرم
کانسی	جھاڑن	جھاڑن
کنڈی	سراب	سراب
دھبہ	یتیم	یتیم
کاجو	ریلا	ریلا

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**Experiment 2a, 2b, and 2c: High-Frequency and Low-Frequency English Target, Identity Prime, and Control Words for the Within-Language Priming Task.**

Frequency	Control	Identity Prime	Target
HFE-HFE			
	AGE	CAR	CAR
	MEAT	CARD	CARD
	PAIR	COAT	COAT
	EXAMPLE	COMPANY	COMPANY
	SIN	GAS	GAS
	MEANING	MACHINE	MACHINE
	CORNER	MINUTE	MINUTE
	ANSWER	POLICE	POLICE
	AGREEMENT	PROFESSOR	PROFESSOR
	FELLOW	REPORT	REPORT
	LADY	BODY	BODY
	HOURL	CITY	CITY
	CHEST	FRUIT	FRUIT
	HEART	HOUSE	HOUSE
	STORY	HUMAN	HUMAN
	HEAT	LAKE	LAKE
	PLACE	NIGHT	NIGHT
	ATTACK	SEASON	SEASON
	WINE	SKIN	SKIN
	MONEY	WOMAN	WOMAN
LFE-LFE			
	DESSERT	BANDAGE	BANDAGE
	PLIGHT	BLOUSE	BLOUSE
	COSMOS	BUCKLE	BUCKLE
	BLIZZARD	LIPSTICK	LIPSTICK
	NECTAR	MARKER	MARKER
	EASEL	PEDAL	PEDAL
	SPIDER	PICNIC	PICNIC
	OMEN	POLO	POLO
	PENDANT	SWEATER	SWEATER
	JUNK	TYRE	TYRE
	SIBLING	BLISTER	BLISTER

PEACOCK	BOUQUET	BOUQUET
NICHE	BRIBE	BRIBE
HERB	CLAP	CLAP
INFIDEL	COCONUT	COCONUT
PHANTOM	CONVICT	CONVICT
BATTER	DUSTER	DUSTER
ANTHEM	MIRAGE	MIRAGE
RIDDLE	ORPHAN	ORPHAN
SLUMBER	TORRENT	TORRENT

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**Experiment 2b: Frequency-Balanced and Frequency-Unbalanced Prime-Target (U-E) Translations Pairs.**

Frequency	Cognates			Noncognates		
	Control Prime	Translation Prime	Target	Control Prime	Translation Prime	Target
HFU-HFE	بستر	کالج	COLLEGE	ٹھنڈ	آنکھ	EYE
	کرسی	ڈگری	DEGREE	مال	ہاتھ	HAND
	تعلیم	ڈاکٹر	DOCTOR	منہ	برف	ICE
	لطف	فلم	FILM	پھول	دودھ	MILK
	متلی	گلاس	GLASS	دھوپ	چاند	MOON
	سال	نام	NAME	سوچ	ناک	NOSE
	مسجد	نمبر	NUMBER	بیٹھ	تیل	OIL
	گود	فون	PHONE	دلہن	کاغذ	PAPER
	سامان	اسکول	SCHOOL	خوشی	دریا	RIVER
	تکلیف	سائنس	SCIENCE	خوشبو	کھڑکی	WINDOW
LFU-LFE	جھنکار	کارٹون	CARTOON	گھٹنہ	کیکڑا	CRAB
	نالہ	کیسٹ	CASSETTE	مکتب	گدھا	DONKEY
	لقمہ	چیتا	CHEETAH	رخسار	باجرا	MILLET
	مجلس	چٹنی	CHUTNEY	ٹخنہ	کشمش	RAISIN
	کاجل	سرکس	CIRCUS	پھٹکری	جھینگا	SHRIMP
	قہر	گٹر	GUTTER	دھمال	گلہری	SQUIRREL
	مخمل	لوشن	LOTION	خندق	درزی	TAILOR
	جوابر	پوسٹر	POSTER	موج	ران	THIGH
	دستک	سلاد	SALAD	مسواک	کانٹا	THORN
	چپاتی	شیمپو	SHAMPOO	سراخ	بٹوا	WALLET
HFU-LFE	استاد	بازار	BAZAAR	گفتگو	بادام	ALMOND
	ساز	چائے	CHAI	خواب	لونگ	CLOVE
	گھاس	گرام	GRAM	ماحول	کھانسی	COUGH
	پتھر	میٹر	METER	دکان	لہسن	GARLIC
	اصول	مسلم	MUSLIM	ساحل	ادرک	GINGER
	بنسی	نواب	NAWAB	شان	دال	LENTIL
	اولاد	پنجاب	PUNJAB	عالم	کنول	LOTUS
	شکار	راجہ	RAJAH	نکتہ	طوطا	PARROT
	نیم	شاہ	SHAH	دولت	بلغم	PHLEGM
	بیٹی	وزیر	VIZIER	چربی	پالک	SPINACH

LFU-HFE

خشخاش	کپتان	CAPTAIN	شوربه	کلیسا	CHURCH
جهول	فائل	FILE	مچھر	قهوه	COFFEE
ٹولی	لیڈر	LEADER	دلیر	صلیب	CROSS
چوغہ	میجر	MAJOR	مالکہ	انجیر	FIG
تعویذ	مارکٹ	MARKET	رُخ	دل	HEART
کیلا	مادر	MOTHER	ڈولی	دوزخ	HELL
چھاپ	پارک	PARK	عظم	خضم	HUSBAND
ہڑتال	اسکیل	SCALE	مشعل	چابی	KEY
بھید	ٹائم	TIME	کنبہ	نشست	SEAT
کھیر	ٹرین	TRAIN	ڈنڈا	آرزو	WISH

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**Experiment 2b and 2c: Frequency-Balanced and Frequency-Unbalanced Prime-Target (E-U) Translations Pairs.**

Frequency	Cognates			Noncognates		
	Control Prime	Translation Prime	Target	Control Prime	Translation Prime	Target
HFE-HFU						
	SURFACE	COLLEGE	کالج	SUN	EYE	آنکھ
	BATTLE	DEGREE	ڈگری	YEAR	HAND	ہاتھ
	FUTURE	DOCTOR	ڈاکٹر	GUN	ICE	برف
	SALT	FILM	فلم	SOIL	MILK	دودھ
	BRAIN	GLASS	گلاس	SNOW	MOON	چاند
	DOOR	NAME	نام	DUST	NOSE	ناک
	FATHER	NUMBER	نمبر	DOG	OIL	تیل
	KNIFE	PHONE	فون	LEVEL	PAPER	کاغذ
	FRIEND	SCHOOL	اسکول	VALUE	RIVER	دریا
	VILLAGE	SCIENCE	سائنس	SPIRIT	WINDOW	کھڑکی
LFE-LFU						
	DRUMMER	CARTOON	کارٹون	HIVE	CRAB	کیکڑا
	PORRIDGE	CASSETTE	کیسٹ	QUARRY	DONKEY	گدھا
	AILMENT	CHEETAH	چیتا	COCOON	MILLET	باجرا
	FLORIST	CHUTNEY	چٹنی	RODENT	RAISIN	کشمش
	BEGGAR	CIRCUS	سرکس	SPLEEN	SHRIMP	جھینگا
	JOCKEY	GUTTER	گٹر	STOCKING	SQUIRREL	گلیہری
	NOZZLE	LOTION	لوشن	PIGEON	TAILOR	درزی
	RANSOM	POSTER	پوسٹر	CHOIR	THIGH	ران
	TOWEL	SALAD	سلاڈ	SPINE	THORN	کانٹا
	KNUCKLE	SHAMPOO	شیمپو	CRATER	WALLET	بٹوا
LFE-HFU						
	CARROT	BAZAAR	بازار	KIDNEY	ALMOND	بادام
	CLAM	CHAI	چائے	BOOZE	CLOVE	لونگ
	FOAL	GRAM	گرام	LEDGE	COUGH	کھانسی
	BUGLE	METER	میٹر	RAVINE	GARLIC	لہسن
	BEAVER	MUSLIM	مسلم	POLLEN	GINGER	ادریک
	CUMIN	NAWAB	نواب	WALRUS	LENTIL	دال
	BANDIT	PUNJAB	پنجاب	VALET	LOTUS	کنول
	GRAVY	RAJAH	راجہ	MORTAR	PARROT	طوطا
	KITE	SHAH	شاہ	PAUNCH	PHLEGM	بلغم
	GOLFER	VIZIER	وزیر	BLEMISH	SPINACH	پالک

## HFE-LFU

RESPECT	CAPTAIN	کپتان	HEALTH	CHURCH	کلیسا
EDGE	FILE	فائل	FINGER	COFFEE	قہوہ
CIRCLE	LEADER	لیڈر	WATCH	CROSS	صلیب
MUSIC	MAJOR	میجر	LEG	FIG	انجیر
FIGURE	MARKET	مارکٹ	VOICE	HEART	دل
MOMENT	MOTHER	مادر	ROOF	HELL	دوزخ
RING	PARK	پارک	SILENCE	HUSBAND	خضم
FLESH	SCALE	اسکیل	HAT	KEY	چابی
BACK	TIME	ٹائم	NECK	SEAT	نشست
YOUTH	TRAIN	ٹرین	WEEK	WISH	آرزو

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## Appendix B

### Language Proficiency Test (Urdu)

یوں تو دنیا میں ہزاروں عمارتیں ایسی ہیں جن کی شان و شوکت اور خوبصورتی دیکھنے کے لائق ہے لیکن شاید ہی کوئی عمارت ایسی خوبصورت اور پرکشش ہو جیسے آگرہ کا تاج محل ہے۔ سفید سنگ مرمر کی بنی ہوئی یہ عمارت ہندوستان میں مغل بادشاہ کا ایک ایسا یادگار کارنامہ ہے جس سے ان کی طبیعت کی نفاست اور نزاکت پسندی کا اظہار ہوتا ہے۔ چاندنی رات میں اس عمارت کو دور سے دیکھنے والوں کو ایسا معلوم ہوتا ہے گویا کسی نے ہیرے سے تراش کر یہ عمارت بنائی ہے۔ اسی لیے تو اسے دنیا کے سات عجائبات میں شمار کیا جاتا ہے۔

تاج محل دراصل شاہجہان نے اپنی چہیتی بیگم ممتاز محل کے مرنے کے بعد اس کے مقبرہ کے طور پر تعمیر کیا تھا۔ ممتاز محل نے وصیت کی تھی کہ اس کی قبر پر ایسا مقبرہ تعمیر کیا جائے جو دنیا میں بے نظیر ہو۔ شاہ جہان نے اپنی پیاری بیگم کی وصیت پوری کی اور لاکھوں روپے، ہزاروں معماروں، کاریگروں، سنگ تراشوں اور صنّاعوں کی محنت سے اسے تعمیر کرایا۔ شاہجہان کو عمارتیں بنانے کا بڑا شوق تھا۔ دہلی اور آگرہ میں اس کی بنائی ہوئی عمارتیں اپنے جلال اور جمال کے اعتبار سے مغل دور کی بہترین عمارتیں ہیں لیکن جو بات تاج محل میں ہے وہ کسی اور عمارت میں نہیں۔ لوگ اسے شاہجہان کا تڑپتا ہوا دل اور اس کی آنکھ کا آنسو کہتے ہیں۔ جس محبت اور جذبے سے اس نے یہ مقبرہ تعمیر کیا وہی جذبہ کسی اور تعمیر کے ساتھ شامل نہ تھا۔ یوں تو تاج محل کا گنبد اور چاروں کونوں کے چار مینار اس کے حسن میں اضافہ کرتے ہیں۔ لیکن اس کی سنگ مرمر کی نازک جالیاں اور دیواروں پر طرح طرح کی گل کاری عجب بہار دکھاتی ہے۔ سارے پھول پتے، سلیں اور نقش و نگار خوبصورت اور قیمتی تھروں سے ہی بنائے گئے ہیں۔ اس طرح کے کام کو پچی کاری کہتے ہیں۔ تھروں سے بنے ہوئے بیل بوٹے دیکھنے والوں کو حیرت میں ڈال دیتے ہیں۔ کیوں کہ بیل بوٹے بالکل اصلی معلوم ہوتے ہیں۔

## Language Proficiency Test (English)

Alice was beginning to get very tired of sitting by her sister on the bank, and of having nothing to do. Once or twice she had peeped into the book her sister was reading, but it had no pictures or conversations in it, "and what is the use of a book," thought Alice, "without pictures or conversations?"

So she was considering in her own mind (as well as she could, for the day made her feel very sleepy and stupid), whether the pleasure of making a daisy-chain would be worth the trouble of getting up and picking the daisies, when suddenly a White Rabbit with pink eyes ran close by her.

There was nothing so very remarkable in that, nor did Alice think it so very much out of the way to hear the Rabbit say to itself, "Oh dear! Oh dear! I shall be too late!" But when the Rabbit actually took a watch out of its waistcoat-pocket and looked at it and then hurried on, Alice started to her feet, for it flashed across her mind that she had never before seen a rabbit with either a waistcoat-pocket, or a watch to take out of it, and, burning with curiosity, she ran across the field after it and was just in time to see it pop down a large rabbit-hole, under the hedge. In another moment, down went Alice after it!

The rabbit-hole went straight on like a tunnel for some way and then dipped suddenly down, so suddenly that Alice had not a moment to think about stopping herself before she found herself falling down what seemed to be a very deep well.

Either the well was very deep, or she fell very slowly, for she had plenty of time, as she went down, to look about her. First, she tried to make out what she was coming to, but it was too dark to see anything; then she looked at the sides of the well and noticed that they were filled with cupboards and book-shelves; here and there she saw maps and pictures hung upon pegs. She took down a jar from one of the shelves as she passed. It was labeled "ORANGE MARMALADE," but, to her great disappointment, it was empty; she did not like to drop the jar, so managed to put it into one of the cupboards as she fell past it.

Down, down, down! Would the fall never come to an end? There was nothing else to do, so Alice soon began talking to herself. "Dinah'll miss me very much to-night, I should think!" (Dinah was the cat.) "I hope they'll remember her saucer of milk at tea-time. Dinah, my dear, I wish you were down here with me!" Alice felt that she was dozing off, when suddenly, thump! thump! down she came upon a heap of sticks and dry leaves, and the fall was over.

## Appendix C

### Language Background Questionnaire

Participant ID \_\_\_\_\_ Gender M / F Age \_\_\_\_\_ Place of Birth \_\_\_\_\_

**This questionnaire is designed to give us a better understanding of your experience with languages. Please try to be as accurate as possible when answering the following questions.**

#### Part A Language History

*SCALE:*

- 1 = Only Urdu
- 2 = Urdu more than English
- 3 = English and Urdu equally
- 4 = English more than Urdu
- 5 = Only English

#### LANGUAGE ACQUISITION

What was your father's native language?

\_\_\_\_\_

What was your mother's native language?

\_\_\_\_\_

*AS A CHILD:*

What language(s) did your father speak with you?	1	2	3	4	5
What language(s) did you speak with your father?	1	2	3	4	5
What language(s) did your mother speak with you?	1	2	3	4	5
What language(s) did you speak with your mother?	1	2	3	4	5
What language(s) did your siblings speak with you?	1	2	3	4	5
What language(s) did you speak with your siblings?	1	2	3	4	5

What language(s) did you speak with you friends?      1      2      3      4      5

Did anyone else take care of you?      Y      N

If yes,

What was his/her native language?

\_\_\_\_\_

What language(s) did he/she speak with you?      1      2      3      4      5

What language(s) did you speak with him/her?      1      2      3      4      5

Have you been exposed to any language other than English and Urdu? Y      N

If yes,

Please specify which language(s)

\_\_\_\_\_

Please describe how you were exposed

\_\_\_\_\_

## EDUCATIONAL HISTORY

How many years of education do you have?

☐ <6yrs

☐ 6-9yrs

☐ 9-12yrs

☐ College/university ( \_\_\_\_ years)

☐ Graduate school ( \_\_\_\_ years)

What was the language of instruction:

In elementary school?      1      2      3      4      5

In middle school?      1      2      3      4      5

In high school?      1      2      3      4      5

In college?      1      2      3      4      5

In graduate school?      1      2      3      4      5

What language(s) did the other students speak:

In elementary school?	1	2	3	4	5
In middle school?	1	2	3	4	5
In high school?	1	2	3	4	5
In college?	1	2	3	4	5
In graduate school?	1	2	3	4	5

What language(s) did you prefer to speak:

In elementary school?	1	2	3	4	5
In middle school?	1	2	3	4	5
In high school?	1	2	3	4	5
In college?	1	2	3	4	5
In graduate school?	1	2	3	4	5

Were you taught in any other language(s)?      Y      N  
 If Yes, please specify which language(s)

\_\_\_\_\_

How many years? \_\_\_\_\_

\_\_\_\_\_

At what age did you first learn Urdu?

\_\_\_\_\_

How did you learn Urdu? (Choose all the options that may apply to you)

☐ Exposure at home

☐ Received Urdu instruction at school

Which grades? \_\_\_\_\_

- ☐ Learned through English materials by yourself
- ☐ Exposure to Urdu in Urdu speaking country/area
- ☐ Practice with native/non-native Urdu speakers
- ☐ \_\_\_\_\_

At what age did you first learn English?

\_\_\_\_\_

How did you learn English? (Choose all the options that may apply to you)

- ☐ Exposure at home
- ☐ Received English instruction at school  
Which grades? \_\_\_\_\_
- ☐ Learned through Urdu materials by yourself
- ☐ Exposure to English in English speaking country/area
- ☐ Practice with native/non-native English speakers
- ☐ \_\_\_\_\_

If you were *not* born in an English speaking province/country, how long have you been living in an English-speaking province/country? \_\_\_\_\_

## Part B Language Use

*SCALE:*

- 1 = Only Urdu
- 2 = Urdu more than English
- 3 = English and Urdu equally
- 4 = English more than Urdu
- 5 = Only English

Rate your language use with the following people:

Father	1	2	3	4	5
Mother	1	2	3	4	5
Partner	1	2	3	4	5
Children	1	2	3	4	5
Grandchildren	1	2	3	4	5
Brothers/sisters	1	2	3	4	5
Friends	1	2	3	4	5
Coworkers	1	2	3	4	5

Rate the frequency with which you do the following in these languages:

Speak	1	2	3	4	5
Listen	1	2	3	4	5
Read	1	2	3	4	5
Write	1	2	3	4	5

Do you speak any language(s) other than Urdu and English?   Y   N

If yes,

Please specify which language(s)

---

**Part C**  
**Language Proficiency**

Please rate your ability in Urdu and English for the following categories:

1 = Non-fluent: only know several words or a few simple sentences

7 = Native Fluency: completely comfortable with skills like a native speaker

<b>URDU</b>	<i>Non-fluent</i>					<i>Native Fluency</i>	
Speaking	1	2	3	4	5	6	7
Comprehension	1	2	3	4	5	6	7
Reading	1	2	3	4	5	6	7
Writing	1	2	3	4	5	6	7
<b>ENGLISH</b>							
Speaking	1	2	3	4	5	6	7
Comprehension	1	2	3	4	5	6	7
Reading	1	2	3	4	5	6	7
Writing	1	2	3	4	5	6	7

Which language do you consider to be your first language?

\_\_\_\_\_

Which language do you consider to be your second language?

\_\_\_\_\_



## Appendix D

### Results From Item Analysis

#### Experiment 1

#### Lexical Decision in English and Urdu Using Frequency-Balanced and Frequency-Unbalanced Cognates and Noncognates

##### Item Analysis

**Reaction Time.** Two separate three-way ANOVAs were carried out one for English and the other for Urdu. The ANOVAs consisted of the following variables: Status (cognate versus noncognate), English Frequency (high versus low), and Urdu Frequency (high versus low). For the English ANOVA, there was a main effect for English Frequency,  $F(1, 72) = 52.045, p < 0.05$ , such that RTs to high-frequency items were faster than RTs to low-frequency items. There was no main effect for Status,  $F(1, 72) = 0.05, p = 0.82$ , nor for Urdu Frequency,  $F(1, 72) = 0.99, p = 0.32$ .

There was an interaction between Status and Urdu Frequency,  $F(1, 72) = 4.449, p < 0.05$ . As shown in Figure 48, cognate words were responded to faster than noncognate words when Urdu Frequency was low. On the other hand, noncognate words were responded to faster than cognate words when Urdu Frequency was high. However, post hoc simple effects analysis indicated that there was no difference in RTs to cognate and noncognate words when the Urdu Frequency was high,  $F(1, 72) = 2.73, p = 0.103$  and when it was low,  $F(1, 72) = 1.77, p = 0.19$ .

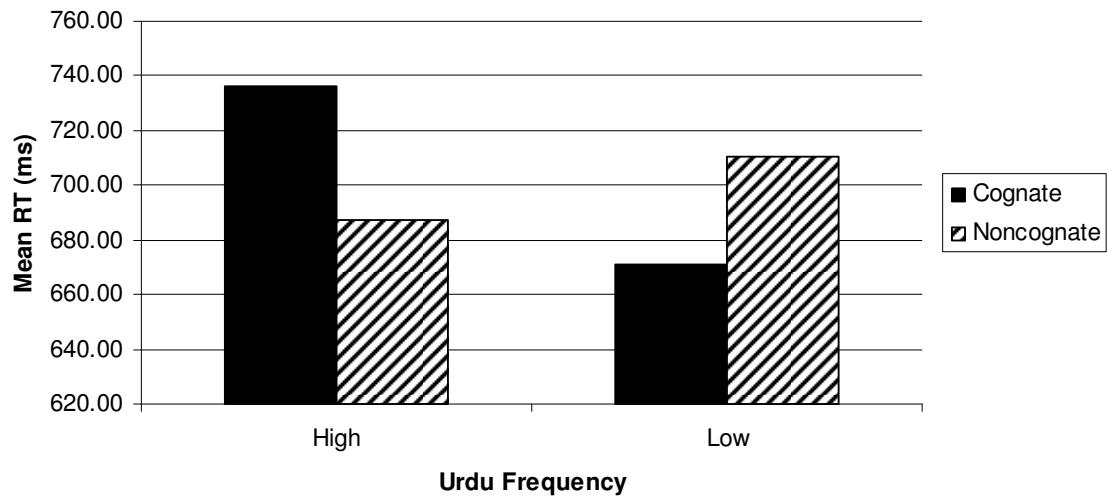


Figure 48. Interaction graph for Status and Urdu Frequency.

There was also an interaction between English Frequency and Urdu Frequency,  $F(1, 72) = 7.736, p < 0.05$ . Post hoc simple effect analysis showed that RTs were shorter for items that had a low frequency in both English and Urdu compared to when they had a low frequency in English only,  $F(1, 72) = 7.124, p < 0.05$ . RTs to items with high frequency in both English and Urdu and items with high frequency in English and low frequency in Urdu were similar,  $F(1, 72) = 1.60, p = 0.210$ . This interaction is shown in Figure 49.

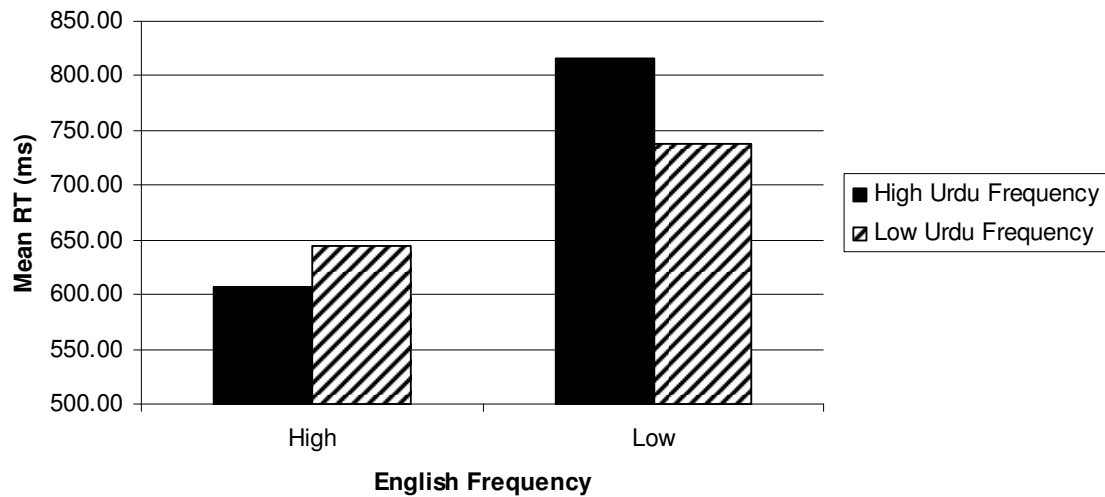


Figure 49. Interaction graph for English Frequency and Urdu Frequency.

There was no two-way interaction between Status and English Frequency,  $F(1, 72) = 0.11, p = 0.75$ . There was no three-way interaction between Status, English Frequency, and Urdu Frequency,  $F(1, 72) = 0.57, p = 0.45$ .

For the Urdu ANOVA, there was a main effect for Urdu Frequency only,  $F(1, 72) = 43.909, p < 0.05$ , such that RTs to high-frequency items were faster than RTs to low-frequency items. There was no main effect for Status,  $F(1, 72) = 2.36, p = 0.13$ ; nor for English Frequency,  $F(1, 72) = 0.99, p = 0.32$ . There was no two-way interaction between Status and Urdu Frequency,  $F(1, 72) = 1.80, p = 0.18$ ; between Status and English Frequency,  $F(1, 72) = 0.01, p = 0.94$ ; and between Urdu Frequency and English Frequency,  $F(1, 72) = 1.11, p = 0.30$ . There was no three-way interaction between Status, Urdu Frequency, and English Frequency,  $F(1, 72) = 0.35, p = 0.56$ .

**Error Rate.** Two separate three-way ANOVAs were carried out one for English and the other for Urdu. The ANOVAs consisted of the following variables: Status (cognate versus noncognate), English Frequency (high versus low), and Urdu Frequency (high versus low). For the English ANOVA, there was a main effect for English Frequency,  $F(1, 72) = 20.446, p < 0.05$ , such that Error Rates for high-frequency items were lower than Error Rates for low-frequency items. There was also a main effect of Urdu Frequency,  $F(1, 72) = 6.656, p < 0.05$ , such that Error Rates for high-frequency Urdu words were higher than those for low-frequency Urdu words. There was no main effect for Status,  $F(1, 72) = 2.86, p = 0.10$ .

There was an interaction between Status and English Frequency,  $F(1, 72) = 5.560, p < 0.05$ , which is shown in Figure 50. Post hoc simple effects analysis revealed that fewer errors were made to noncognate words compared to cognate words when the English Frequency was low,  $F(1, 72) = 8.18, p < 0.05$ . On the other hand, the error rate was similar for cognate and noncognate words with high English frequency,  $F(1, 72) = 0.22, p = 0.64$ .

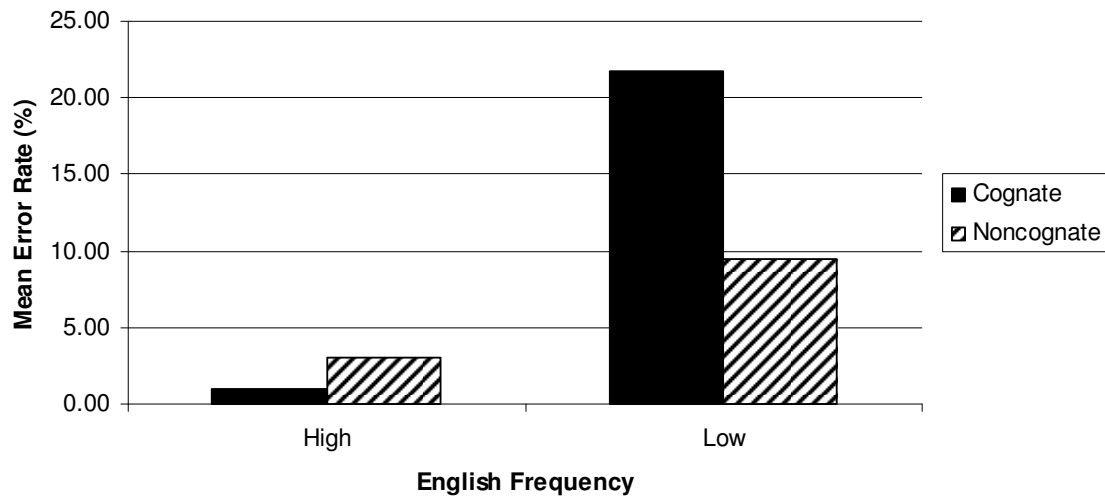


Figure 50. Interaction graph for Status and English Frequency.

There was an interaction between English Frequency and Urdu Frequency,  $F(1, 72) = 8.484, p < 0.05$ . Post hoc simple effects analysis revealed that when English Frequency was low, fewer errors were made to words with high frequency in Urdu compared to words with low frequency in Urdu,  $F(1, 72) = 15.35, p < 0.05$ . When English Frequency was high, there was no difference in error rates to words with high- and low- Urdu frequency,  $F(1, 72) = 0.08, p = 0.80$ . This interaction is shown in Figure 51.

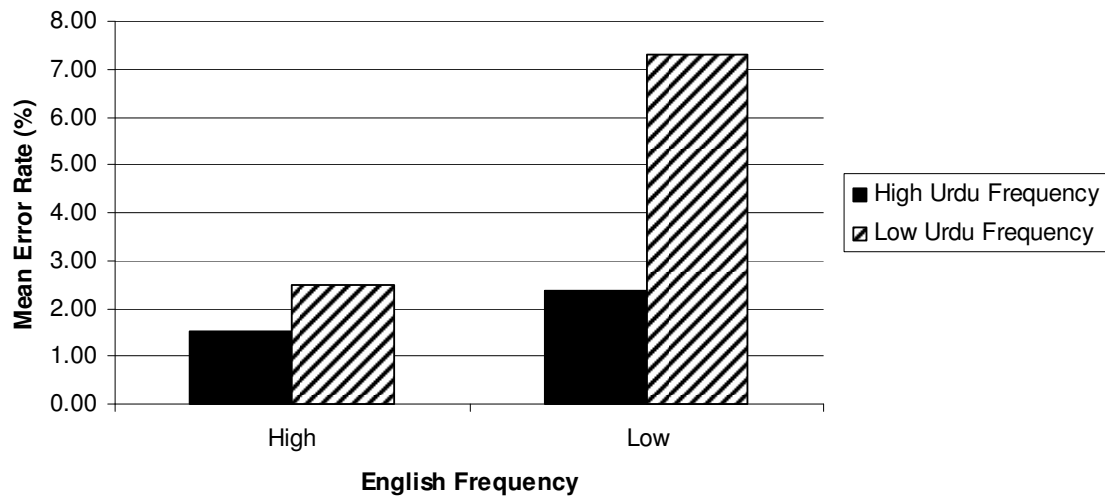


Figure 51. Interaction graph for Urdu Frequency and English Frequency.

There was no two-way interaction between Status and Urdu Frequency,  $F(1, 72) = 3.20, p = 0.08$ . There was no three-way interaction between Status, English Frequency, and Urdu Frequency,  $F(1, 72) = 2.02, p = 0.16$ .

For the Urdu ANOVA, there was a main effect for Urdu Frequency,  $F(1, 72) = 20.229, p < 0.05$ , such that Error Rates for high-frequency items were lower than Error Rates for low-frequency items. There was also a main effect for English Frequency,  $F(1, 72) = 4.992, p < 0.05$ , such that Error Rates for high-frequency English words were higher than those for low-frequency English words. There was no main effect for Status,  $F(1, 72) = 0.10, p = 0.75$ .

There was an interaction between Urdu Frequency and English Frequency,  $F(1, 72) = 5.880, p < 0.05$ . Post hoc simple effects analysis revealed that such that fewer errors were made to words that were low frequency in both Urdu and English than to words that were low frequency in Urdu only,  $F(1, 72) = 10.78, p < 0.05$ . There was no

difference in error rates between words that were high frequency in both Urdu and English and those that were high frequency in Urdu only,  $F(1, 72) = 0.015$ ,  $p = 0.902$ .

This interaction is shown in Figure 52.

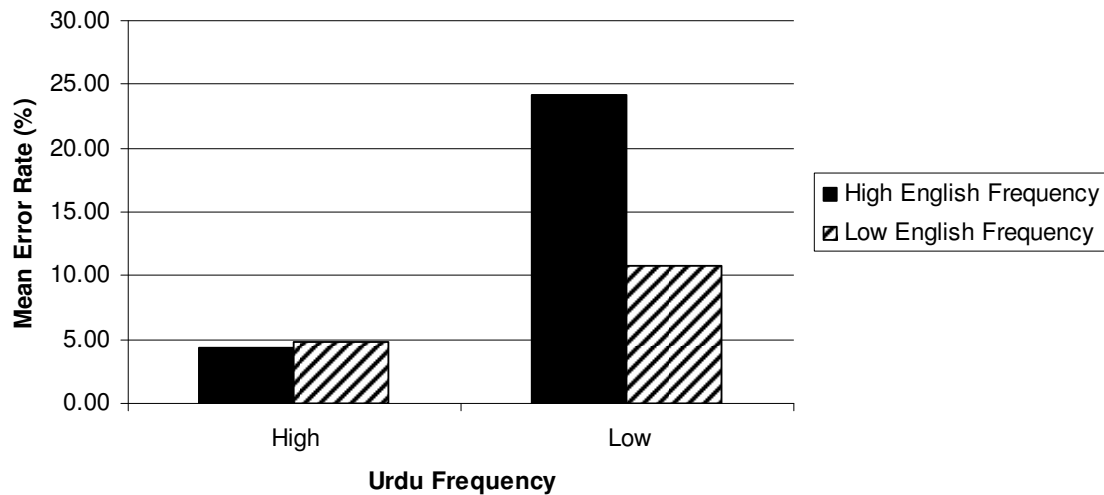


Figure 52. Interaction graph for Urdu Frequency and English Frequency.

There was no two-way interaction between Status and Urdu Frequency,  $F(1, 72) = 0.71$ ,  $p = 0.40$ ; and between Status and English Frequency,  $F(1, 72) = 1.56$ ,  $p = 0.22$ .

There was no three-way interaction between Status, Urdu Frequency, and English Frequency,  $F(1, 72) = 2.74$ ,  $p = 0.10$ .

## Experiment 2a

### Within-Language Masked Priming in English (E-E) and Urdu (U-U) at 30 ms SOA

#### Within Language Priming in English (E-E)

#### Reaction Time

**Item Analysis.** An ANOVA was carried out such that, Prime Type (identity versus unrelated) was treated as a within-item variable, whereas Frequency (high versus low) and Group (item group) were treated as between-item variables. The last factor was introduced by the counterbalancing procedure and removed variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach).

There was a main effect for Prime Type,  $F(1,36) = 6.185, p < 0.05$ , such that when target words were preceded by identity primes they were responded to faster than when they were preceded by unrelated primes. There was a main effect for English Frequency,  $F(1,36) = 27.805, p < 0.05$ , such that high-frequency words were responded to faster than low-frequency words. There was no interaction between Prime Type and English Frequency,  $F(1,36) = 0.047, p = 0.829$ .

### **Error Rate**

**Item Analysis.** An ANOVA was carried out such that, Prime Type (identity versus unrelated) was treated as a within-item variable, whereas Frequency (high versus low) and Group (item group) were treated as between-item variables. The last factor was introduced by the counterbalancing procedure and removed variance due to this procedure (Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach).).

There was no main effect for Prime Type,  $F(1,36) = 0.177, p = 0.677$ . There was a main effect for English Frequency,  $F(1,36) = 4.774, p < 0.05$ , such that fewer errors were made to high-frequency words than to low-frequency words. There was no interaction between Prime Type and English Frequency,  $F(1,36) = 1.589, p = 0.216$ .

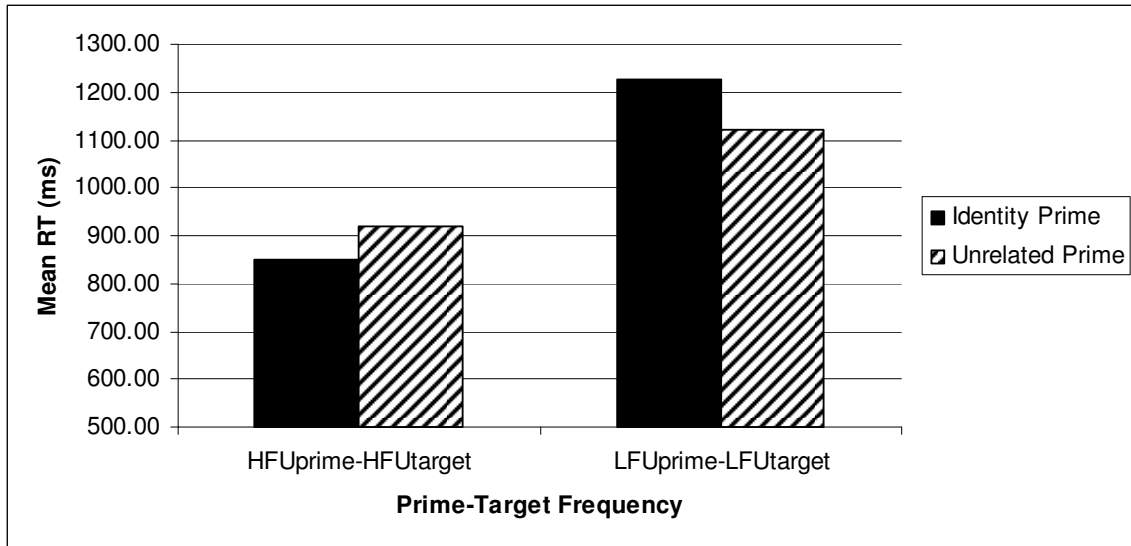


### Within Language Priming in Urdu (U-U)

#### Reaction Time

**Item Analysis.** An ANOVA was carried out such that, Prime Type (identity versus unrelated) was treated as a within-item variable, whereas Frequency (high versus low) and Group (item group) were treated as between-item variables. The last factor was introduced by the counterbalancing procedure and removed variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach).

There was no main effect for Prime Type,  $F(1,36) = 0.301, p = 0.587$ . There was a main effect for Urdu Frequency,  $F(1,36) = 52.153, p < 0.05$ , such that high-frequency words were responded to faster than low-frequency words. There was an interaction between Prime Type and Urdu Frequency,  $F(1,36) = 6.601, p = 0.014$ . Post hoc simple effects analysis revealed that low-frequency Urdu words preceded by identity primes were responded to *slower* than those preceded by unrelated primes,  $F(1,36) = 4.861, p < 0.05$ , i.e., there was a *reverse* priming effect. For high-frequency Urdu words the priming effect was in the correct direction but this effect was not statistically significant,  $F(1,36) = 2.041, p = 0.162$ . See Figure 53.



*Figure 53.* Within-Language RT latencies (ms) for high-frequency Urdu (HFU) and low-frequency Urdu (LFU) prime-target pairs.

### Error Rate

**Item Analysis.** An ANOVA was carried out such that, Prime Type (identity versus unrelated) was treated as a within-item variable, whereas Frequency (high versus low) and Group (item group) were treated as between-item variables. The last factor was introduced by the counterbalancing procedure and removed variance due to this procedure (Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach).

There was no main effect for Prime Type,  $F(1,36) = 0.303$ ,  $p = 0.585$ . There was a main effect for Urdu Frequency,  $F(1,36) = 21.307$ ,  $p < 0.05$ , such that fewer errors were made to high-frequency words than to low-frequency words. There was no interaction between Prime Type and Urdu Frequency,  $F(1,36) = 0.681$ ,  $p = 0.415$ .

## Experiment 2b

### Masked Priming from Urdu to English (NL-DL) at 50 ms SOA and from English to Urdu (DL-NL) at 30 ms SOA Using Frequency-Balanced and Frequency-Unbalanced Cognates and Noncognates

## Results

### Within Language Priming in English (E-E)

#### Reaction Time

**Item Analysis.** An ANOVA was carried out such that, Prime Type (identity versus unrelated) was treated as a within-item variable, whereas Frequency (high versus low) and Group (item group) were treated as between-item variables. The last factor was introduced by the counterbalancing procedure and removed variance due to this procedure (Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach).

There was no main effect for Prime Type,  $F(1,36) = 1.556, p = 0.220$ . There was a main effect for Frequency,  $F(1,36) = 42.571, p < 0.05$ , such that high-frequency words were responded to faster than low-frequency words. There was no interaction between Prime Type and Frequency,  $F(1,36) = 0.061, p = 0.807$ .

#### Error Rate

**Item Analysis.** An ANOVA was carried out such that, Prime Type (identity versus unrelated) was treated as a within-item variable, whereas Frequency (high versus low) and Group (item group) were treated as between-item variables. The last factor was introduced by the counterbalancing procedure and removed variance due to this

procedure (Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach).

There was no main effect for Prime Type,  $F(1,36) = 0.145$ ,  $p = 0.706$ . There was a main effect for Frequency,  $F(1,36) = 6.569$ ,  $p < 0.05$ , such that fewer errors were made to high-frequency words than to low-frequency words.

There was no interaction between Prime Type and Frequency,  $F(1,36) = 0.788$ ,  $p = 0.381$ .

### **Within Language Priming in Urdu (U-U)**

#### **Reaction Time**

**Item Analysis.** An ANOVA was carried out such that, Prime Type (identity versus unrelated) was treated as a within-item variable, whereas Frequency (high versus low) and Group (item group) were treated as between-item variables. The last factor was introduced by the counterbalancing procedure and removed variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach).

There was a main effect for Prime Type,  $F(1,36) = 6.883$ ,  $p < 0.05$ , such that identity primes were responded to faster than unrelated primes. There was a main effect for Frequency,  $F(1,36) = 45.111$ ,  $p < 0.05$ , such that high-frequency words were responded to faster than low-frequency words. There was no interaction between Prime Type and Frequency,  $F(1,36) = 0.101$ ,  $p = 0.753$ .

#### **Error Rate**

**Item Analysis.** An ANOVA was carried out such that, Prime Type (identity versus unrelated) was treated as a within-item variable, whereas Frequency (high versus

low) and Group (item group) were treated as between-item variables. The last factor was introduced by the counterbalancing procedure and removed variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach).

There was no main effect for Prime Type,  $F(1,36) = 0.031$ ,  $p = 0.862$ . There was a main effect for Frequency,  $F(1,36) = 15.896$ ,  $p < 0.05$ , such that fewer errors were made to high-frequency words than to low-frequency words.

There was no interaction between Prime Type and Frequency,  $F(1,36) = 0.003$ ,  $p = 0.960$ .

### **Cross Language Priming from Urdu to English (U-E)**

#### **Reaction Time**

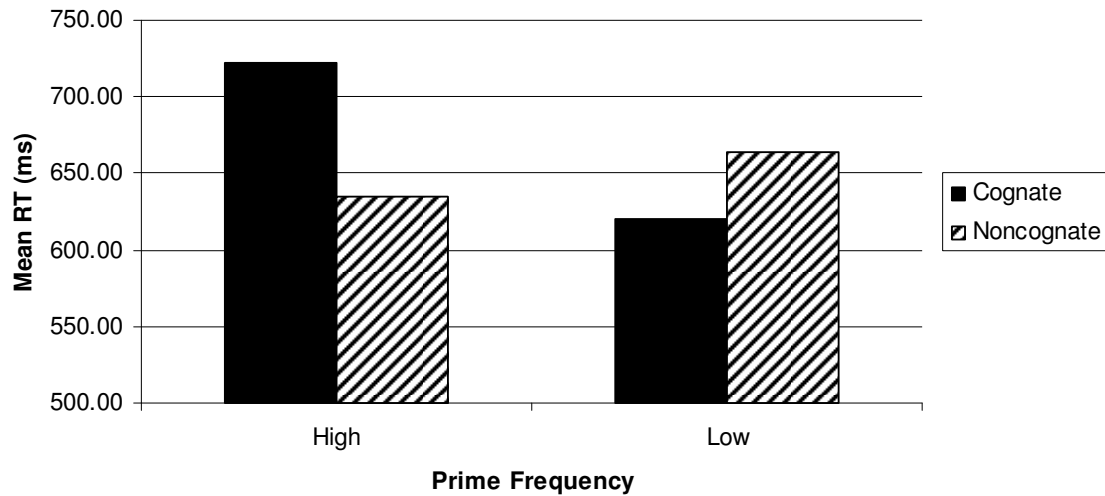
**Item Analysis.** In the item analysis, Prime Type was treated as a within-item variable, whereas Status, Target Frequency, Prime Frequency, and Group (item group) were treated as between-item variables. The last factor was introduced by the counterbalancing procedure and removed variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach).

There was no main effect for Prime Type,  $F(1,64) = 0.159$ ,  $p = 0.691$ ; for Status,  $F(1,64) = 0.480$ ,  $p = 0.491$ ; or for Prime Frequency,  $F(1,64) = 1.324$ ,  $p = 0.254$ . There was a main effect for Target Frequency,  $F(1,64) = 15.508$ ,  $p < 0.05$ , such that high-frequency words were responded to faster than low-frequency words.

There was an interaction between Status and Prime Frequency,  $F(1,64) = 4.185$ ,  $p = 0.045$ . Post hoc simple effects analysis revealed that when Prime Frequency was high,

RTs to cognates were slower than RTs to noncognates,  $F(1,64) = 3.749$ ,  $p = 0.057$ .

However, when Prime Frequency was low, RTs to cognates were faster than RTs to noncognates, although the difference was not statistically significant,  $F(1,64) = 0.916$ ,  $p = 0.342$ . The interaction graph is shown in Figure 54.



*Figure 54.* Mean Reaction Time in milliseconds for cognate and noncognate words as a function of Prime Frequency (high vs. low).

There was no interaction between Prime Type and Status,  $F(1,64) = 0.034$ ,  $p = 0.855$ ; between Prime Type and Target Frequency,  $F(1,64) = 0.640$ ,  $p = 0.427$ ; between Prime Type and Prime Frequency,  $F(1,64) = 0.038$ ,  $p = 0.845$ ; between Status and Target Frequency,  $F(1,64) = 0.913$ ,  $p = 0.343$ ; and between Target Frequency and Prime Frequency,  $F(1,64) = 2.396$ ,  $p = 0.127$ .

There was no three-way interaction between Status, Prime Type and Prime Frequency,  $F(1,64) = 0.007$ ,  $p = 0.934$ ; between Prime Type, Target Frequency, and

Prime Frequency,  $F(1,64) = 3.080, p = 0.084$ ; between Status, Target Frequency, and Prime Frequency,  $F(1,64) = 0.807, p = 0.372$ ; and between Status, Prime Type, and Target Frequency,  $F(1,64) = 3.608, p = 0.062$ .

There was no four-way interaction between Status, Prime Type, Prime Frequency, and Target Frequency,  $F(1,64) = 0.170, p = 0.681$ .

### **Error Rate**

**Item Analysis.** In the item analysis, Prime Type was treated as a within-item variable, whereas Status, Prime Frequency, Target Frequency, and Group (item group) were treated as between-item variables. The last factor was introduced by the counterbalancing procedure and removed variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; Voga & Grainger, 2007, for prior examples of this approach).

There was no main effect for Prime Type,  $F(1,64) = 0.034, p = 0.855$ ; for Status,  $F(1,64) = 0.020, p = 0.887$ ; or for Prime Frequency,  $F(1,64) = 1.830, p = 0.181$ . There was a main effect for Target Frequency,  $F(1,64) = 13.184, p < 0.05$ , such that fewer errors were made to high-frequency words than to low-frequency words.

There was an interaction between Prime Frequency and Target Frequency,  $F(1,64) = 4.827, p < 0.05$ . Post hoc simple effects analysis revealed that fewer errors were made when low-frequency target words were primed by low-frequency words compared to when they were primed by high-frequency words,  $F(1,64) = 6.30, p < 0.05$ . On the other hand, the error rate was similar when high-frequency target words were primed by high-frequency words and when they were primed by low-frequency words,  $F(1,64) = 0.356, p = 0.553$ . This interaction is shown in Figure 55.

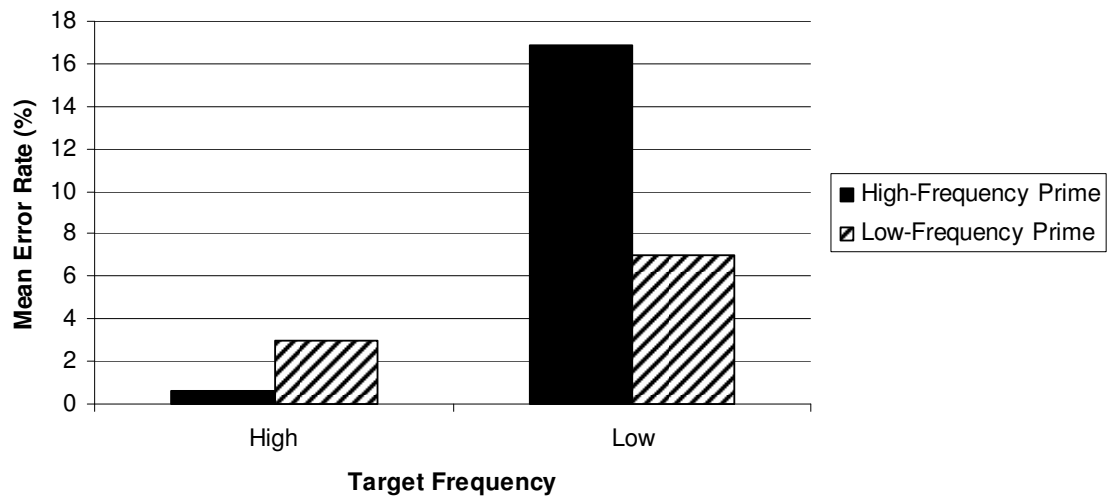


Figure 55. Interaction graph for Target Frequency and Prime Frequency.

There was no interaction between Prime Type and Status,  $F(1,64) = 0.635$ ,  $p = 0.428$ ; between Prime Type and Target Frequency,  $F(1,64) = 0.790$ ,  $p = 0.377$ ; between Prime Type and Prime Frequency,  $F(1,64) = 0.076$ ,  $p = 0.784$ ; between Status and Prime Frequency,  $F(1,64) = 2.816$ ,  $p = 0.098$ ; and between Status and Target Frequency,  $F(1,64) = 0.157$ ,  $p = 0.693$ .

There was no three-way interaction between Prime Type, Status, and Target Frequency,  $F(1,64) = 0.497$ ,  $p = 0.483$ ; between Prime Type, Status, and Prime Frequency,  $F(1,64) = 0.339$ ,  $p = 0.562$ ; between Prime Type, Target Frequency, and Prime Frequency,  $F(1,64) = 0.304$ ,  $p = 0.583$ ; and between Status, Prime Frequency, and Target Frequency,  $F(1,64) = 3.502$ ,  $p = 0.066$ .

There was no four-way interaction between Prime Type, Status, Prime Frequency, and Target Frequency,  $F(1,64) = 0.736$ ,  $p = 0.394$ .



## Experiment 2c

### Masked Priming from English to Urdu (DL-NL) at 50 ms SOA Using Frequency-

### Balanced and Frequency-Unbalanced Cognates and Noncognates

### Within Language Priming in English (E-E)

## Results

### Reaction Time

**Item Analysis.** An ANOVA was carried out such that, Prime Type (identity versus unrelated) was treated as a within-item variable, whereas Frequency (high versus low) and Group (item group) were treated as between-item variables. The last factor was introduced by the counterbalancing procedure and removed variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach).

There was a main effect for Prime Type,  $F(1,36) = 14.147, p < 0.05$ , such that identity primes were responded to faster than unrelated primes. There was a main effect for English Frequency,  $F(1,36) = 13.643, p < 0.05$ , such that high-frequency words were responded to faster than low-frequency words. There was no interaction between Prime Type and Frequency,  $F(1,36) = 1.009, p = 0.322$ .

### Error Rate

**Item Analysis.** An ANOVA was carried out such that, Prime Type (identity versus unrelated) was treated as a within-item variable, whereas Frequency (high versus low) and Group (item group) were treated as between-item variables. The last factor was introduced by the counterbalancing procedure and removed variance due to this

procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach).

There was no main effect for Prime Type,  $F(1,36) = 0.172, p = 0.681$ . There was a main effect for English Frequency,  $F(1,36) = 13.208, p < 0.05$ , such that fewer errors were made to high-frequency words than to low-frequency words. There was no interaction between Prime Type and English Frequency,  $F(1,36) = 0.396, p = 0.533$ .

### **Cross Language Priming from English to Urdu (E-U)**

#### **Reaction Time**

**Item Analysis.** In the item analysis, Prime Type was treated as a within-item variable, whereas Status, Urdu Frequency, English Frequency, and Group (item group) were treated as between-item variables. The last factor was introduced by the counterbalancing procedure and removed variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach).

There was no main effect for Status,  $F(1,64) = 2.999, p = 0.088$ . There was a main effect for Prime Type,  $F(1,64) = 12.701, p < 0.05$ , such that translation primes were responded to faster than unrelated primes. There was a main effect for Target Frequency,  $F(1,64) = 25.039, p < 0.055$ , such that high-frequency words were responded to faster than low-frequency words. There was no main effect for Prime Frequency,  $F(1,64) = 1.624, p = 0.207$ .

There was no interaction between Prime Type and Status,  $F(1,64) = 2.809, p = 0.099$ ; between Prime Type and Target Frequency,  $F(1,64) = 1.978, p = 0.164$ ; between Prime Type and Prime Frequency,  $F(1,64) = 0.060, p = 0.807$ ; between Status and Target

Frequency,  $F(1,64) = 0.028$ ,  $p = 0.868$ ; between Status and Prime Frequency,  $F(1,64) = 0.305$ ,  $p = 0.583$ ; and between Target Frequency and Prime Frequency,  $F(1,64) = 2.623$ ,  $p = 0.110$ .

There was no three-way interaction between Status, Target Frequency, and Prime Frequency,  $F(1,64) = 3.227$ ,  $p = 0.077$ ; between Prime Type, Status, and Target Frequency,  $F(1,64) = 0.004$ ,  $p = 0.950$ ; between Prime Type, Status, and Prime Frequency,  $F(1,64) = 0.009$ ,  $p = 0.924$ ; and between Prime Type, Target Frequency, and Prime Frequency,  $F(1,64) = 0.490$ ,  $p = 0.486$ .

There was no four-way interaction between Prime Type, Status, Urdu Frequency, and English Frequency,  $F(1,64) = 2.009$ ,  $p = 0.161$ .

### **Error Rate**

**Item Analysis.** In the item analysis, Prime Type was treated as a within-item variable, whereas Status, Urdu Frequency, English Frequency, and Group (item group) were treated as between-item variables. The last factor was introduced by the counterbalancing procedure and removed variance due to this procedure (see Pollatsek & Well, 1995; also Gollan et al., 1997; Kim & Davis, 2003; and Voga & Grainger, 2007, for prior examples of this approach).

There was no main effect for Prime Type,  $F(1,64) = 1.190$ ,  $p = 0.279$ ; Status,  $F(1,64) = 1.244$ ,  $p = 0.269$ ; and Prime Frequency,  $F(1,64) = 1.522$ ,  $p = 0.222$ . There was a main effect for Target Frequency,  $F(1,64) = 10.334$ ,  $p < 0.05$ , such that fewer errors were made to high-frequency words than to low-frequency words.

There was an interaction between Target Frequency and Prime Frequency,  $F(1,64) = 7.262$ ,  $p < 0.05$ . Post hoc simple effect analysis revealed that more errors were

made to low-frequency Urdu targets preceded by high-frequency English primes compared to when they were preceded by low-frequency English primes,  $F(1,64) = 7.717, p < 0.05$ . However, the error rate was similar when high-frequency Urdu targets were preceded by high-frequency English primes and when they were preceded by low-frequency English primes,  $F(1,64) = 1.067, p = 0.305$ . This interaction is shown in Figure 56.

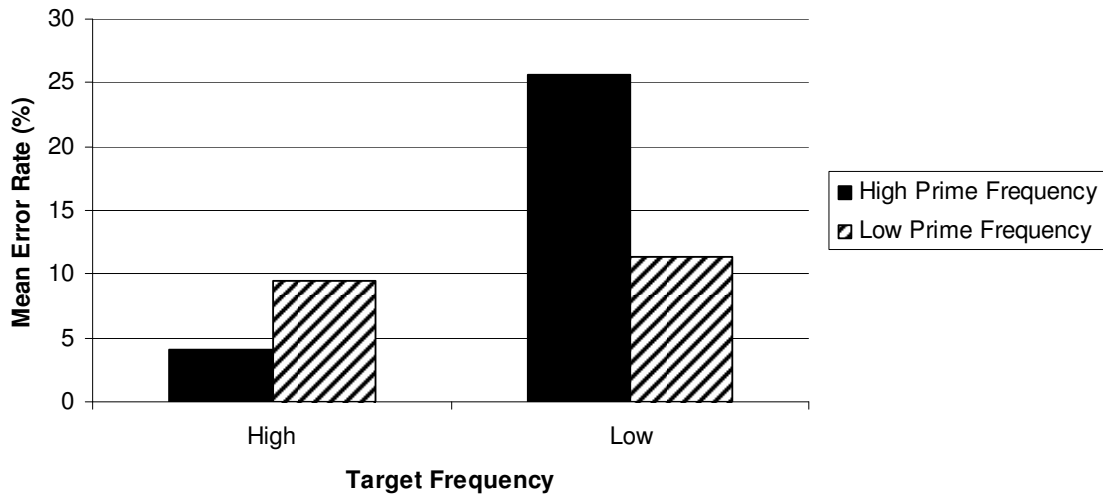


Figure 56. Interaction graph for Target Frequency and Prime Frequency.

There was no interaction between Status and Target Frequency,  $F(1,64) = 0.519, p = 0.4748$ ; between Status and Prime Frequency,  $F(1,64) = 1.411, p = 0.239$ ; between Prime Type and Status,  $F(1,64) = 0.872, p = 0.354$ ; between Prime Type and Target Frequency,  $F(1,64) = 2.390, p = 0.127$ ; and between Prime Type and Prime Frequency,  $F(1,64) = 0.059, p = 0.809$ .

There was no three-way interaction between Status, Target Frequency, and Prime Frequency,  $F(1,64) = 1.572, p = 0.215$ ; between Prime Type, Status, and Target Frequency,  $F(1,64) = 0.653, p = 0.422$ ; between Prime Type, Status, and Prime Frequency,  $F(1,64) = 1.886, p = 0.174$ ; and between Prime Type, TargetFrequency, and Prime Frequency,  $F(1,64) = 0.022, p = 0.882$ .

There was a four-way interaction between Status, Prime Type, Target Frequency, and Prime Frequency,  $F(1,64) = 5.215, p < 0.05$ .

## Appendix E

### Correlation and ANCOVA Statistics

Table 28

*Correlation Between RT and Proficiency for Experiments 1, 2a, 2b, and 2c.*

Experiment	Measure	English Proficiency	Urdu Proficiency
1			
	English RT	-0.41*	
	Urdu RT		-0.58*
2a			
E-E	English RT	-0.28	
U-U	Urdu RT		-0.84**
2b			
E-E	English RT	-0.67**	
U-U	Urdu RT		-0.72**
U-E	English RT	-0.52*	
2c			
E-E	English RT	-0.38	
E-U	Urdu RT		-0.72**

*Note.* \* $p < 0.05$ , \*\* $p < 0.01$

Table 29

*The Results of 2 (Language: English Vs. Urdu) x 2 (Status: Cognate Vs. Noncognates) x 2 (English Frequency: High Vs. Low) x 2 (Urdu Frequency: High Vs. Low) Repeated Measures Analysis of Covariance for Experiment 1 (Subject Analysis).*

Effect	Reaction Time		
	<i>df</i>	<i>F</i> value	<i>p</i> value
Main Effect			
English Proficiency (centered covariate)	(1, 27)	1.35	=0.26
Urdu Proficiency (centered covariate)	(1, 27)	2.90	=0.10
Language	(1, 27)	68.7	<0.05
Status	(1, 27)	1.42	=0.24
English Frequency	(1, 27)	90.99	<0.05
Urdu Frequency	(1, 27)	43.79	<0.05
Two-Way Interaction			
Language x Status	(1, 27)	2.52	=0.12
Language x English Frequency	(1, 27)	18.34	<0.05
Language x Urdu Frequency	(1, 27)	89.72	<0.05
Status x English Frequency	(1, 27)	1.05	=0.32
Status x Urdu Frequency	(1, 27)	8.64	<0.05
English Frequency x Urdu Frequency	(1, 27)	11.97	<0.05
Three-Way Interaction			
Language x Status x English Frequency	(1, 27)	1.39	=0.25
Language x Status x Urdu Frequency	(1, 27)	2.45	=0.13
Language x English Frequency x Urdu Frequency	(1, 27)	6.15	<0.05
Status x English Frequency x Urdu Frequency	(1, 27)	0.001	=0.98
Four-Way Interaction			
Language x Status x English Frequency x Urdu Frequency	(1, 27)	3.68	=0.07

Table 30

*The Results of 2 (Prime Type: Identity Vs. Unrelated) x 2 (Frequency: High Vs. Low)  
Repeated Measures Analysis of Covariance for Experiment 2a (Subject Analysis).*

Language	Effect	Reaction Time		
		<i>df</i>	<i>F</i> value	<i>p</i> value
English-English	Main Effect			
	English Proficiency (centered covariate)	(1, 10)	0.75	=0.41
	Prime Type	(1, 10)	7.69	<0.05
	Frequency	(1, 10)	16.95	<0.05
	Two-Way Interaction			
Urdu-Urdu	Prime Type x Frequency	(1, 10)	0.03	=0.88
	Main Effect			
	Urdu Proficiency (centered covariate)	(1, 10)	41.68	<0.05
	Prime Type	(1, 10)	0.41	=0.54
	Frequency	(1, 10)	146.87	<0.05
	Two-Way Interaction			
	Prime Type x Frequency	(1, 10)	7.43	<0.05



Table 31

*The Results of 2 (Prime Type: Identity Vs. Unrelated) x 2 (Frequency: High Vs. Low)  
Repeated Measures Analysis of Covariance for Experiment 2b.*

Language	Effect	Reaction Time		
		<i>df</i>	<i>F</i> value	<i>p</i> value
English-English	Main Effect			
	English Proficiency (centered covariate)	(1, 16)	13.42	<0.05
	Prime Type	(1, 16)	1.73	=0.21
	Frequency	(1, 16)	59.9	<0.05
	Two-Way Interaction			
Urdu-Urdu	Prime Type x Frequency	(1, 16)	0.27	=0.61
	Main Effect			
	Urdu Proficiency (centered covariate)	(1, 16)	18.46	<0.05
	Prime Type	(1, 16)	12.41	<0.05
	Frequency	(1, 16)	110.14	<0.05
	Two-Way Interaction			
	Prime Type x Frequency	(1, 16)	0.58	=0.46

Table 32

*The Results of 2 (Status: Cognate Vs. Noncognates) x 2 (Prime Type: Translation Vs. Unrelated) x 2 (English Frequency: High Vs. Low) x 2 (Urdu Frequency: High Vs. Low) Repeated Measures Analysis of Covariance for Experiment 2b.*

Language	Effect	Reaction Time		
		<i>df</i>	<i>F</i> value	<i>p</i> value
Urdu-English	Main Effect			
	English Proficiency (centered covariate)	(1, 15)	3.63	=0.08
	Urdu Proficiency (centered covariate)	(1, 15)	0.06	=0.81
	Status	(1, 15)	0.17	=0.69
	Prime Type	(1, 15)	0.17	=0.69
	Target Frequency	(1, 15)	37.59	<0.05
	Prime Frequency	(1, 15)	0.22	=0.65
	Two-Way Interaction			
	Status x Prime Type	(1, 15)	0.54	=0.48
	Status x Target Frequency	(1, 15)	0.38	=0.55
	Status x Prime Frequency	(1, 15)	20.25	<0.05
	Prime Type x Target Frequency	(1, 15)	0.62	=0.44
	Prime Type x Prime Frequency	(1, 15)	0.61	=0.45
	Target Frequency x Prime Frequency	(1, 15)	5.54	=0.03
	Three-Way Interaction			
	Status x Prime Type x Target Frequency	(1, 15)	1.72	=0.21
	Status x Prime Type x Prime Frequency	(1, 15)	0.30	=0.59
	Status x Target Frequency x Prime Frequency	(1, 15)	0.001	=0.98
	Prime Type x Target Frequency x Prime Frequency	(1, 15)	3.63	=0.08
	Four-Way Interaction			
	Status x Prime Type x Target Frequency x Prime Frequency	(1, 15)	1.25	=0.28

Table 33

*The Results of 2 (Prime Type: Identity Vs. Unrelated) x 2 (Frequency: High Vs. Low)  
Repeated Measures Analysis of Covariance for Experiment 2c.*

Language	Effect	Reaction Time		
		<i>df</i>	<i>F</i> value	<i>p</i> value
English-English	Main Effect			
	English Proficiency (centered covariate)	(1, 18)	4.64	0.05
	Prime Type	(1, 18)	12.85	<0.05
	Frequency	(1, 18)	24.91	<0.05
	Two-Way Interaction			
	Prime Type x Frequency	(1, 18)	0.81	=0.38

Table 34

*The Results of 2 (Status: Cognate Vs. Noncognates) x 2 (Prime Type: Translation Vs. Unrelated) x 2 (English Frequency: High Vs. Low) x 2 (Urdu Frequency: High Vs. Low) Repeated Measures Analysis of Covariance for Experiment 2c.*

Language	Effect	Reaction Time		
		<i>df</i>	<i>F</i> value	<i>p</i> value
Urdu-English	Main Effect			
	English Proficiency (centered covariate)	(1, 16)	3.40	=0.08
	Urdu Proficiency (centered covariate)	(1, 16)	0.09	=0.77
	Status	(1, 16)	0.16	=0.69
	Prime Type	(1, 16)	0.94	=0.35
	Target Frequency	(1, 16)	16.00	<0.05
	Prime Frequency	(1, 16)	1.82	=0.20
	Two-Way Interaction			
	Status x Prime Type	(1, 16)	4.29	=0.06
	Status x Target Frequency	(1, 16)	1.89	=0.19
	Status x Prime Frequency	(1, 16)	1.93	=0.18
	Prime Type x Target Frequency	(1, 16)	0.02	=0.90
	Prime Type x Prime Frequency	(1, 16)	0.29	=0.60
	Target Frequency x Prime Frequency	(1, 16)	1.45	=0.25
	Three-Way Interaction			
	Status x Prime Type x Target Frequency	(1, 16)	0.42	=0.53
	Status x Prime Type x Prime Frequency	(1, 16)	3.65	=0.07
	Status x Target Frequency x Prime Frequency	(1, 16)	0.32	=0.58
	Prime Type x Target Frequency x Prime Frequency	(1, 16)	0.83	=0.38
	Four-Way Interaction			
	Status x Prime Type x Target Frequency x Prime Frequency	(1, 16)	0.42	=0.53

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